Bulletin; Gulf Biologic Station
no. 5, 1906; no. 6, 1906

with regards of L. R. Cary

GULF BIOLOGIC STATION

CAMERON, LA.

BULLETIN No. 6.

ISSUED BY THE

LOUISIANA STATE BOARD OF AGRICULTURE AND IMMIGRATION.

CHAS. SCHULER, Commissioner.

BATON ROUGE.
THE TIMES, OFFICIAL JOURNAL OF LOUISIANA.
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CAMERON, LA., (Mouth of Calcasieu Pass).

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L. R. CARY, M. S., Zoologist in Charge of Field Oyster Investigations.

M. H. SPAULDING, Zoologist in Charge of Experimental Work.

M. W. MCCALL, Custodian of Station Laboratory.

FRANK ROBERTS, Treasurer.

Baton Rouge, La.,

His Excellency, Governor N. C. Blanchard, President of the Board of Control of Gulf Biologic Station, Baton Rouge, Louisiana.

Sir—I beg to submit the report of some of the investigations made by scientists in the employ of the Gulf Biologic Station at Cameron and the Chandeleur Island regions in the eastern part of Louisiana. This bulletin represents a part of the report of the work of the Station for the last two years. It has been preceded by Bulletins Nos. 3, 4 and 5.

Respectfully submitted,

B. H. GUILBEAU.

Hon. Chas. Schuler, Commissioner of Agriculture and Immigration, Baton Rouge, La.:

Sir—I herewith present to you the report of some of the investigations made by scientists in the employ of the Gulf Biologic Station at Cameron and the Chandeleur Island regions in the eastern part of the State, and ask that you publish them as Bulletin No. 6 of the Gulf Biologic Station.

Very respectfully,

B. H. GUILBEAU, Director.

CONTENTS.

Gulf Biologic Station

OF LOUISIANA.

BULLETIN No. 6. JUNE, 1906.

Further Studies

ON THE

Oyster at Calcasieu Pass.

By L. R. CARY.

The following report is based upon investigations carried on at the Gulf Biologic Station, Cameron, La., during the spring of 1905 and in March and April, 1906.

During the summer of 1904 Dr. J. L. Kellogg and Dr. R. P. Cowles were engaged at the station studying problems relating to oyster culture in Louisiana waters; and, beside those problems to which definite answers were given in Dr. Kellogg's report, Bulletin No. 3 of the Gulf Biologic Station, a number of experments were begun by these workers the outcome of which could be determined only at a later date.

Having at hand the data concerning these unfinished experiments, the work for the season of 1905 was planned to keep up the experiments previously started; to make further investigations pertaining to the particular conditions prevailing in Calcasieu Pass, and consider more general problems, the results of which would be applicable to the oyster producing regions of the State as a whole.

CONDITIONS IN CALCASIEU PASS DURING THE SEASON OF 1905.

At the time of my arrival at Cameron, May 8, 1905, the water in the pass was absolutely fresh to a depth of sixteen feet, and according to the best information obtainable, the same con-

dition had prevailed for the past month or six weeks. For four weeks after this date, the water was continually fresh on the surface at the laboratory wharf, one-fourth of a mile in from the jetties. During this period the current in the river was running down, at least on the surface, almost continually; the intervals when there was any appreciable current running up being restricted to times when there was a strong breeze from the south or southeast. Even during the occurrence of a flood tide th~~is~~e salinity of the water in the pass seldom became appreciably raised, since, on account of the great volume of fresh water carried down during the longer periods of ebb tide, the water in the Gulf near the mouth of the pass was fresh for a distance of two miles off shore. The salinity of samples of water taken at the sea buoy one and one-half miles from the jetties during May and the first half of June, varied between 1.00 and 1.0031, while the line of separation where the fresh muddy water from the pass met the clear blue water of the Gulf was, opposite the mouth of the pass, from one and one-half to three miles off shore.

The salinity of the water from several places in the pass was determined at least once a day, usually in the morning, and whenever any unusual condition, such as the occurrence of a marked current running up the river prevailed; a series of determinations at the different stations were made supplementing the regular daily observations. The stations where these determinations were made were as follows: 1, at the laboratory wharf; water was taken here at the surface and at one foot above the bottom—six to seven feet of water being found here; 2, over an oyster reef in sixteen to twenty feet of water, near the boat landing of the Calcasieu light house; 3, from the surface and near the bottom at a point near the outer end of the east jetty. Beside these stations where the salinity was recorded daily, observations were made on the water over the other reefs in the pass as they were visited from time to time in the course of the work. At times when there was salt water over the reef near the light house, samples of water were taken from over the other reefs in the lower part of the pass in order to determine how far up the river the flow of salt water ascended.

THE RELATION BETWEEN THE DEPTH OF WATER AND ITS SALINITY.

Over the reef in the upper part of the pass and those at the mouth of St. Johns Bayou, the water was always fresh, even in the deepest places, irrespective of the direction of the current. In the lower part of the pass there was, however, a noticeable difference in the salinity of water taken from the surface and that taken from a depth of from twelve to twenty feet.

The following table gives a condensed account of the difference in salinity of water from different depths taken over the "Light House" reef.

TABLE 1.

Date.	Direction of Current.	Salinity. Surface.	Salinity. 16 Feet.
May 8th.	Down	1.000	1.000
May 9th	"	1.000	1.002
May 10th	"	1.000	1.004
May 11th	"	1.000	1.0042
May 12th	"	1.000	1.0035
May 13th	Up	1.000	1.0051
May 14th	Down	1.000	1.0029
May 15th	"	1.000	1.0033
May 16th	"	1.000	1.0046
May 17th	"	1.000	1.0039
May 18th	"	1.000	1.0047
May 19th	Up	1.000	1.0051
May 20th	"	1.000	1.0073
June 1st	Down	1.000	1.0035
June 2d	"	1.000	1.0074
June 4th	Up	1.0052	1.0095
June 6th	"	1.010	1.012
June 8th	Down	1.0085	1.011

As shown in the table, the water was always more saline at the greater depth and, at a depth of 16 feet, the salinity was sufficient to allow the oysters to maintain life.

The reef over which the water was taken to make the salinity records given in the previous table, begins above low water mark and extends out toward the channel to a depth of about

twenty-two feet. By collecting oysters from different depths it was possible to observe the limits within which the water was fresh for a sufficient length of time to kill all the oysters, and running down from this level to find the proportion of living oysters at the different depths. All the oysters living above low tide mark and those down to a depth of six feet below that level were dead, while with an increasing depth of water the proportion of living individuals increased rapidly, although, even at a depth of sixteen feet many of them had succumbed before the time when the water became normal.

TABLE 2.

Percentage of living oysters at different depths on the Lighthouse reef, June 6, 1905:

Depth of water.	Percent. of living oysters.	Percent. hinged shells.
Above low water mark	0.0	100.0
3 feet	0.0	100.0
6 feet	0.0	100.0
10 feet	46.0	54.0
12 feet	62.0	38.0
16 feet	98.0	2.0

The liquids contained within the shells of living oysters from any part of the pass were always considerably more saline than the water in the river at the time these were taken up, so that it was apparent that the valves were opened only when the water was at its maximum salinity.

On the 6th of June the water in the pass became salty as far up as the lake, and from this date until June 21 the salinity averaged 1.0014 at the laboratory wharf.

After a heavy rain on June 22 the water again became absolutely fresh. From this date until late in October the water was fresh, except for intervals of one or two days at a time, when there would be brackish water in the lower part of the

* Only those dead shells, of which the hinges were intact showing that the oysters had been dead a short time only, were counted in determining the percentages given in this table.

pass. While these periods when the water was brackish were of sufficient frequency to maintain the life of the oysters on the deepest beds in the lower part of the pass, they were not of sufficient length to establish the normal economy of the pass and allow the growth of an abundance of food organisms or to provide the conditions necessary for the breeding of the oysters and the growth of the young.

CONDITIONS ON THE JETTIES.

Dr. Glaser, in his report on the conditions for oyster culture in Calcasieu Pass, calls attention to the fact that the condition of the oysters on the rocks forming the jetties at the mouth of the pass is very different from that of the ones growing on the reefs farther up the pass. The relatively greater number of the jetty oysters that survived, as well as the superior condition of the survivors, although subjected to practically the same physical conditions, shows the importance of determining, if possible, to what particular factor or factors the difference is due.

The factor that is of the most importance in determining the condition and quality of these oysters is undoubtedly the fact that they are attached to the stones of the jetties. On these comparatively smooth surfaces there is room for each oyster to grow to its normal shape, and, even if those of another generation settle on the ones already present, there is not the tendency to lateral crowding that there is among the oysters on the natural reefs. The oysters on the rocks are attached by the whole surface of one valve, and themselves form a comparatively flat surface parallel to that of the place of attachment, while those on the natural reefs are attached at one end only, with the open end of the shells standing up nearly vertical and crowding at the sides. The jetty oysters are in most instances attached some distance above the bottom, so that they are removed from any danger of becoming covered up by a deposit of sediment, and do not suffer the inconvenience of taking in this sediment when they are feeding.

The amount of food available for each individual here is greater than on the reefs, for in this latter instance, where the

oysters are densely crowded, it is probable that the water is strained by a number of different ones as it passes over the reef, making the number of food organisms captured by each oyster comparatively small. The currents are always swifter some distance above than close to the bottom, so that the chance of the food content of the water being depleted is less. In times of freshet the more saline water from the gulf reaches the jetty oysters before it reaches those farther up in the pass; and where the current begins to run down again the water becomes fresh here later than over the other reefs, so that the period when conditions are suitable for feeding is more prolonged.

The fact that the jetty oysters begin a period of freshet in better condition than those on the reefs has probably a marked relation to their ability to withstand these conditions for a longer period than their less fortunate neighbors.

EFFECT OF THE FRESHET ON THE BEGINNING AND DURATION OF THE BREEDING SEASON.

Although under normal conditions the breeding season of the oyster begins in Louisiana waters some time during April or in the early part of May, no spat could be found on shells in the pass previous to June 6th, which date marked the beginning of a period of two weeks when the water in the pass was brackish; although for some weeks previous to this date artificial fertilization of the eggs had shown that the sexual products of the oysters from all the reefs were ripe. Whether the oysters had been throwing out eggs and sperms previous to this date, ~~or~~ and the absence of spat is to be accounted for by the fact that on account of the prevalence of fresh water the embryos were unable to develop, or whether the matured sexual products were retained by the adults until the physical conditions should become such as to make possible the development of the young, is a question to which a definite answer cannot at present be given. However, the unusual prolongation of the breeding season into the late fall, when a set of spat was secured at a season when oysters are usually spawning only sporadically, lends support to the belief that the spawning activities were limited to times when

the external conditions were such as to allow, if not assure, the development of the embryos.

During the two weeks from the 6th to the 21st of June the oysters in the lower part of the pass were spawning actively, and all the clean shells on the reefs below Leesburg became covered with a good set of spat. The average number of spat on each one hundred shells from the different reefs was as follows:

TABLE 3.

Location of reef.	No. of spat per shell.
One-quarter mile below Leesburg	36
One-half mile below Leesburg	97
Lighthouse Reef	132

While all the clean shells below Leesburg, both on the natural reefs and in cages, showed a good set of spat, none of the shells in the upper part of the pass or in St. John Bayou were found with spat attached, although, as has been previously mentioned, the physical conditions were suitable for the growth of young oysters.

The absence of any spat on shells from the reefs in this part of the pass when conditions were favorable for their growth lends support to the conclusion reached as a result of tonging on these beds, namely, that there were no living oysters even in the deepest water at the upper part of the pass. This point has an important bearing on the question of the distance that spats may travel before the time of their attachment, as will be discussed farther on in this report.

The spawning activities of the oysters ceased with the beginning of the period of fresh water on June 21, or at least all setting of spat ceased, and no further catch of spat occurred until late in the fall. During the first two weeks of this second period of freshet most of the young oysters had succumbed to the effects of the fresh water or had been covered up by the sediment, so that during the summer very few spats could be found, and those only on the deepest reefs.

RECOVERY FROM THE EFFECTS OF FRESHETS.

When the reefs in Calcasieu Pass were examined for the last time, in the summer of 1905, they were, with the exception of the ones in the deep water near the lower part of the pass, practically extinct; and in the case of the reefs near the head of the pass there were no adults to serve as breeding oysters to restock the depleted reefs. When examined again in the early part of March, 1906, the shells on all the reefs in the pass and in St. John Bayou showed a good growth of young oysters, varying in diameter from one twenty-fifth to two and a half inches. On the reefs in the upper part of the pass the set was not at all heavy, although practically all the shells examined had a few spat attached.

TABLE 4.

Average number of young oysters on each one hundred shells from different reefs in Calcasieu Pass in March, 1906:

Location of reef.	Number of young oysters.
Reef at upper end of pass	5.67
East Twin Reef	6.75
Reef at mouth of St. John Bayou	6.15
Reef one-quarter mile below Leesburg	13.00
Reef one-half mile below Leesburg	18.47
Lighthouse Reef	26.72

Although the number of young per shell is in each instance comparatively small, still, when we take into account the fact that the examinations were made some four months after the set was secured, and that most of the young were from one to two inches long, and so past the most critical stage of their existence, as was shown by the larger number of small dead spats on each shell, the present condition of these beds assures a continued productivity. The small number of young present on each shell will prevent the crowding so common among the oysters on these reefs, and thus assure a better quality of oysters than could have been produced had the "set" been as heavy as is usual in these waters.

The same prolongation of the breeding season beyond its usual limits was observed at several other points along the coast during the past season. In Vermilion Bay, where there were heavy freshets during the past spring, the oysters were breeding in the latter part of October and in the early part of November, while young oysters of a size such as would have been normal for spat set in the spring were found only occasionally. On the reefs in the open gulf near-by, where the effects of the freshets were not felt to any great extent, young oysters were present whose size showed plainly that they had settled at the time of the usual breeding season in the spring.

TRANSFER OF SPAT.

A definite answer to the question of how far an oyster embryo may travel during its active free-swimming state would be of immense value to the oyster culturist, both as concerns the recovery of beds depleted by freshets or other destructive agents and also as affording a basis from which to calculate the probability of obtaining a set of spat on clutch exposed on bottoms at a distance from any natural reefs. The principal factor that determines the distribution of the fry is undoubtedly the currents in the water, the activity of the embryo itself never being sufficient to offset even a comparatively weak current. Judging from the time that oyster embryos, secured by artificial fertilization of the eggs, are known to keep moving about actively, it is safe to assume that under favorable conditions the embryos might be carried for long distances from the point where the eggs were fertilized.

The conditions that existed at Cameron during the past season made it possible for one to give a definite statement that, under conditions by no means especially favorable, oyster embryos may be carried at least four miles.

As was mentioned earlier in this report, it was shown conclusively that there were no living adult oysters in the pass above Leesburg during the latter part of June; so all the spat for the new growth must have come from reefs in the lower part of the pass. These reefs are at least four miles from the one nearest the lake at the head of the pass. The presence of spat

on nearly all of the shells on the reefs in the upper part of the pass shows that the embryos must have been abundant in the water over these reefs at that time in their development when they were ready to become attached.

The distance of four miles, given as the least that any of the spat on the reef nearest the head of the pass must have traveled, is probably less than the actual distance from which most of them must have come, since by far the greater number of breeding oysters were on the reefs about two miles below Leesburg, and thus one and one-half miles farther away.

The currents prevailing in the pass are usually much stronger during ebb than during flood tide, the difference being most noticeable in the shallow water over the reefs in the upper part of the pass, where, under normal conditions, the current is running down most of the time. No determinations of the comparative lengths of the periods of flood and ebb tides were made during the time when the spat were settling on the reefs in the upper part of the pass; but it is probable that the comparative duration and strength of the tides were not different than at other times.

As the result of these conditions it naturally follows that only those embryos that began their free-swimming period near the beginning of flood tide were at all likely to be carried to the upper part of the pass, while those becoming actively motile after flood or early ebb tide would find their place of attachment in the lower part of the pass, or else be carried out into the waters of the gulf.

Although positive assurance of securing a set of spat in any particular locality can be given only after experimental proof, an assurance well within the bounds of probability can be given when one has studied the currents in that region, provided there are present adult oysters to furnish the spat.

The size of the area over which a set of spat was secured in Calcasieu Pass during the past fall shows, when the comparatively small number of breeding oysters is taken into account, that a few adult oysters have great power for restocking a depleted bed or for providing a set of spat on any clutch exposed in their vicinity.

In connection with the question of reclaiming depleted reefs or establishing new beds, the results observed at Cameron during the past season have an important bearing on the question of the comparative value of planting clutch or bedding seed oysters.

There are on the coast of Louisiana large areas of bottom, now barren, where in the past there were well defined reefs that produced many hundreds of barrels of oysters annually. As the result of overfishing and improper culling, many of these reefs have entirely disappeared, so that at the present time there is scarcely anything to distinguish their former location from the surrounding bottom, and under the action of natural causes alone there is no reason to assume that new reefs will be formed any more rapidly than was the case in the formation of all natural reefs. On some few of these old reefs there are still sufficient shells to form a hard crust, but these shells are so covered with sediment, algae, sponges and other animals as to make them practically worthless as spat collectors. These shells are being rapidly disintegrated by the action of boring mollusks, boring sponges and the action of the waves and unless some steps are ~~action is~~ taken to save the already hardened bottom it will be only a question of a few years before these areas will be indistinguishable from the soft bottom surrounding them.

The method of planting seed oysters—young oysters taken from the natural reefs—has been the one most frequently used by oyster culturists in this State; but as the supply of seed is yearly becoming less and less, and the distance that the seed must be transported is constantly increasing on account of the depletion of the natural reefs near the non-producing regions, the cost of this method of planting is increasing and the profit becoming correspondingly lessened.

Beside the question of comparative cost of the two methods, there should also be considered the fact that while the value of the transplanted seed oysters is very much increased, there is no addition to the yield of a locality beside what may be accounted for by the increased size and quality of the oysters. On the other hand, by using the method of exposing "clutch"—clean shells or other suitable material—for catching spat, not only is the initial expense lessened, but also the natural reefs

are not depleted, bottom not available for bedding may be used, and, above all other considerations, every oyster grown on such artificial beds is a direct addition to the supply existing in the waters of the State.

Practical demonstrations of the utility of this method of oyster culture in the hands of oyster culturists may be found in the North Atlantic fields and, to a limited extent, in the fields of this State also. The restocking of the depleted reefs in Calcasieu Pass, previously mentioned in this report, as well as the practical workings of this method in some few instances in the waters of Louisiana, establish beyond any doubt the utility of this method for the Louisiana fields.

In regions where there are at present no oysters it would be necessary to bring in some adult oysters to furnish spat to stock the plants for the first season; but when once started the beds are self-perpetuating, and the number of spat caught would be in direct proportion to the amount of clean clutch exposed at each breeding season. Observations made at Cameron by Dr. Kellogg in 1904 demonstrated that under favorable conditions oysters in Louisiana waters become sexually mature in one year, so that a few adult oysters brought into a barren region where there was proper clutch would assure immense numbers of spat at the second breeding season, and thus make possible the rapid reclamation of barren areas without necessitating any further importation of breeding oysters.

Any bottom where there is not the danger of the shells being covered up by deposits of sediment may be sufficiently hardened by an application of shells, 2,000 to 5,000 bushels per acre being used. The amount of shell necessary will, of course, depend on the character of the particular area under consideration.

Records of the known rate of growth of oysters in some of the Louisiana fields give the assurance that within two years from the time of the setting of spat oysters of a marketable size will have been producing in any region where physical and biological conditions are favorable.

As the result of observations extending over a period of three years, made in the North Carolina oyster fields, Dr. Grave says in his report: "It is better to strew shells and stock beds

from spat than to plant large seed oysters. The latter do not recover from the shock they have undergone in the rough handling and in sudden change in their habitat until spat caught at the time of planting seed oysters have attained an equal size." The results of these experiments are applicable to the Louisiana fields, and speak strongly in favor of the latter method of planting.

RATE OF GROWTH.

During the past two seasons considerable attention was given to observations and experiments having for their result a definite determination of the rate of growth of oysters in Louisiana waters. A definite answer to this point would serve as a certain basis for the comparison of Louisiana and Atlantic fields, and also serve to clear up some of the conflicting statements made concerning the possibilities of growth in local waters. While records of phenomenal growth are of interest, what is of real value to the perspective oyster culturist is a knowledge of the average growth that may reasonably be expected from the oysters over a whole bed, rather than to know the maximum growth that will at best be attained by a few individuals only.

In his report for 1904, Dr. Kellogg gives the measurements of ten oysters, approximately one year old, that average 3.07 inches in length from the umbo to the opposite shell margin. In May, 1906, measurements were made of oysters grown in the same place—the piles under the laboratory wharf—as those measured by Dr. Kellogg in 1904. The lengths were as follows: 2.50, 3.00, 2.75, 3.25, 3.50, 2.25, 3.00, 3.25, 2.75, 3.50 inches. The average length is 2.97 inches. These oysters were well rounded, and the length from hinge to shell margin in a good shaped oyster represents a much greater volume than the same length of shell in an oyster that has been crowded during its growth. These oysters were approximately eleven months old, assuming that the spat settled on the piles within a few days after these were put in place.

It is probable that these oysters had grown very slowly, if

at all, during the last two months they were in the water, on account of the freshet that had prevailed during that time. These figures agree very closely with those given by Dr. Kellogg for the season before, so that a growth of three inches may be taken as an average year's growth in these waters under favorable conditions.

On the reefs in the upper part of the pass, when first visited in the early part of May, 1905, many of the oysters had only recently died, as was shown by the presence of the decomposing bodies within the shells. As most of these oysters were known to have settled in the spring and summer of 1903, they were thus not more than two years old at the time of their death, and the length of shells from these reefs will give an idea of the growth during the second season. Many of these shells were measured at different times, and the lengths of ten, representing fairly the usual size, were as follows: 5.75, 6.50, 4.00, 5.25, 6.25, 7.00, 4.75, 6.75, 5.50, 3.75 inches. The average length is 5.65 inches. The oysters on these reefs had been crowded during their growth, and besides, the ratio between length and width increases with the age of an oyster, so that an oyster grown in a cluster does not have as great a volume as one the same length grown on a flat surface where there is no resistance to its expansion in width as well as in length.

In order to definitely ascertain the rate of growth of oysters under conditions as similar as possible to those existing on the natural reefs, Dr. Kellogg placed on the Lighthouse Reef a number of cages, made of wire netting, and filled with clean shells. The cage that was left to determine the year's growth was placed in position on June 22, 1904. On August 5, 1905, shells were removed from this cage and the young measured. A number of these shells with spat up to one-half inch in diameter as the result of not more than six weeks' growth are figured in Dr. Kellogg's report. During a heavy storm in February ~~of~~ 1905 this cage was washed away from its former location on the reef, and all attempts to find it during the spring of 1905 were fruitless. While tonging on the outer, deep portion of this reef March 23, 1906, this cage was brought up. Although the

greater part of the contents had been lost, a number of the *Arca* shells with oysters attached remained and many young oysters of about the same size as those on the clutch were attached to the netting of the cage. The length in inches from umbo to opposite shell margin of ten oysters from the cage was as follows: 2.50, 2.25, 4.00, 3.25, 2.50, 2.75, 3.00, 3.00, 2.25, 2.75, giving an average length of 2.75 inches.

In the light of what we know of the rate of growth of oysters on the wharf piles and on the reefs in the pass, it seems improbable that the oysters found in the cage can be any of those that settled in the cage in the summer of 1904. The fact that the cage was put down in shallow water, where during the extreme low tides caused by a "norther" it was exposed, makes it appear probable that any oysters present in it at the time of the freshet in the spring of 1905 as were all those on the reef at the same level. In the deep water where the cage rested after the change from its first position many of the spat formed in June, 1905, lived through the summer, and it seems most likely that the ones found in the cage were eight months rather than a year and eight months of age. Some of the area shells remaining in the cage had empty oyster shells attached of about the same size as the living oysters; but, as these shells were covered with sediment and overgrown with hydroids, both inside as well as out, they had been dead for a longer time than could have been the case had they come from the same set of spat as the living oysters present with them in the cage.

The growth of the young oysters on the reefs in the upper part of the pass, when we take into account that the set of spat did not occur until late in October, and consequently the growth has taken place in the winter season, when, on account of the low temperature of the water, growth is always slowest, is very encouraging. As the result of not over five months' growth during that part of the season when growth is always slowest there is an abundance of young oysters of sizes ranging between one and one-half and two and one-half inches. In all the counts of young oysters made during March and April of this year a record of the sizes of the young growth was kept, and always the num-

ber above one and one-half inches was greater than the number of those of smaller size. The present growth, instead of being elongated, as is usually the case on reefs surrounded by soft mud, are all well rounded and have the maximum volume for their length.

CONDITIONS IN THE OPEN GULF.

While at the Station two summers ago Dr. Kellogg started some experiments to determine the feasibility of establishing oyster beds in the open waters of the gulf near Cameron. The conditions existing in the gulf at a depth of eighteen or twenty feet were, according to Dr. Kellogg's observations, very favorable for the growth of oysters, with the one exception of the character of the bottom, or rather, the fluctuating character of the bottom. The instability of the bottom was due apparently to the deposition of large amounts of sediment brought down by the water of the river in times of freshet and deposited in the shallow waters of the gulf, forming a layer several inches in thickness as the result of the sediment brought down during a single heavy rain.

During May and June of 1905 observations on the amount of sediment in the water of the river and on the area of distribution of this sediment in the gulf were made, covering a period of several weeks. Samples of water were taken from the channel between the jetties, where the current was always swift. One liter was measured out and allowed to settle until all the sediment had collected in a definite layer on the bottom of the graduate, leaving the water in the upper part of the vessel perfectly clear. The volume of the sediment was then read off from the bottom of the graduate and the percentage by volume calculated. The contents of the graduate were then filtered, the precipitate dried at 100 degrees Centigrade, and weighed after being cooled in a desiccator.

The results of these observations are given in the following table:

TABLE 5.

Percentages by volume and by weight of the sediment in the water in Calcasieu Pass during May and June, 1906:

Date of examination.	Percent. by weight of sediment.	Percent. by volume of sediment.
May 10	1.74	8.93
May 12	2.14	10.23
May 13	1.87	9.42
May 15	2.29	14.37
May 17	2.01	11.03
May 18	1.68	8.74
May 20	1.52	7.63
May 22	1.63	8.27
May 25	1.27	6.46
May 28	0.48	2.28
June 1	0.25	1.13
June 5	0.09	0.27

Although it was impossible to determine the volume of water flowing in the river, and thus get an approximate estimate of the amount of sediment brought down into the gulf in a given period of time, the fact that the current ran down most of the time, that its velocity varied from two to three and one-half miles per hour, and that the narrowest place between the jetties is three hundred and twenty-five yards across, may help one to from a conception of the amount of silt brought down during a protracted freshet, when the water contains from six to ten parts of sediment.

The area over which the sediment was deposited could be traced along the shore by a deposit of soft mud left on the usually bare beach after each high tide, while the seaward limit of deposition was taken to be at that point where the water changed in appearance from the muddy water of the river to the clear blue water of the gulf. The currents in the gulf due to wind, as well as the regular tidal currents, made the limits of this area very variable from day to day. However, the limits may

be given as follows: For a distance of four miles on either side of the mouth of the pass there was a deposit of soft mud after each period when the water was high. The layer of sediment was thickest near the jetties and scarcely perceptible at the limits mentioned above. The distance off shore of the line of separation between the muddy and the clear water varied very much, sometimes as much as a half-mile difference being noted in the course of a single day. Usually the line of separation was about two miles beyond the jetties, but at times it was more than a mile beyond this point.

The deposit of sediment on the beach usually washed away rapidly, except where it was above the usual high tide level, so that within four or five days after a heavy deposit the beach would be clean until the time when another exceptionally high tide caused a fresh deposit to be laid down.

That the disappearance of the shells put down in the gulf was due to their being covered up by sediment, and not the result of the settling of the shells because of their weight, was maintained by Dr. Kellogg. As proof of this statement he cites the behavior of a bed of the same sort of small shells put down on the soft mud near the laboratory wharf at the time when the gulf plants were made. This bed was not nearly as thick as the one in the gulf, and yet after a year and a half from the time of its deposition the limits of this bed are clearly defined and the shells above the mud. While the construction of these beds was in progress, a number of barrels of adult oysters were thrown overboard a little way above the laboratory wharf, on a very soft bottom, without any previous application of hardening agents. Practically, all of these oysters were above the mud at the time of their examination in March of this year, and yet a pole could be thrust into the mud beside the bed for a distance of six feet.

These facts support Dr. Kellogg's contention that his plants did not settle in the soft mud, and besides, are of value in that they show how easily a bottom apparently useless for growing oysters may be brought into a condition such that it will afford ample support for a bed of oysters.

FATE OF THE GULF PLANTS.

Of the two plants made in the gulf in 1904, one to the east and one to the west of the jetties, only the east plant was found during the past season. The buoys marking the location of both these beds were carried away during the winter of 1904. That from the east bed was found near the beach at least a mile from the bed, while the one that had marked the location of the west bed was never seen after February of 1905, when it was reported to have been in position by Captain Ford, who carried the shells to make the gulf plants. After the date when the east bed was located it was visited on several occasions and a sounding pole used to determine whether or not any of the shells were still above the mud. Although the depth of the deposit of sediment on the bed varied at the different examinations, there was only one time when any part of the plant was above the mud. Usually the higher part of the bed, made by dumping a schooner load of shells in two piles, was covered by two to six inches of mud, while over the greater part of the surface of the bed the mud was from twelve to forty inches deep. When last visitetd, on March 24, 1906, the depth of the mud over the bed was three and one-half feet, so that all chance of the erosion of the sediment was apparently hopeless.

Shells taken from this bed at different times during the summer of 1905 were always thickly covered with mud, and never in any instance showed the presence of any spat; so it is probable that all the shells, and the adult oysters as well, had been permanently covered up before the beginning of the breeding season in 1905.

The outcome of the experiments just described demonstrates the impracticability of attempting to utilize for cultural purposes bottoms in the open gulf near the mouth of rivers where there is likely to be heavy deposits of sediment after each heavy rain. It should be understood however, that these results are not to be assumed to apply to the shallow parts of the gulf as a whole, but only to areas where there is particular danger of a heavy deposit of sediment. In places farther removed from the mouths of rivers this danger will be done away with,

if not wholly, at least to a great extent, and, where the physical and biological conditions are favorable, better success may be expected from an experimental plant. That the conditions for the growth of oysters, except for the fatal mud deposit, are favorable in the waters of the gulf near Calcasieu Pass was clearly shown during the seasons of 1904 and 1905. In May, 1904, the buoys marking the entrance to the pass were changed, clean and newly painted ones being substituted for those that had been in place for a year. In a storm some time during the winter of 1904-05, the outer buoy one and one-half miles from the jetties dragged its anchor and drifted about two miles to the westward and in-shore from its former position. When this buoy was examined one day near the middle of June, it was found to be covered with an abundant growth of oysters. The length in inches of ten of these was as follows: 3.25, 3.50, 2.75, 2.50. 3.00, 3.00, 3.25, 2.50, 3.75, 3.25. The average length is 3.075 inches. These oysters were of very good shape and in excellent condition at the time when they were found. Their condition remained very good while the oysters on the reefs in the pass were very poor or had succumbed to the effects of the prolonged action of fresh water and sediment. The continued condition of these oysters when those in the pass had perished, as well as their rapid growth, gives an assurance that as soon as some method of overcoming the destructive effects of the mud deposit is found, or when beds are established beyond the limits of damage from this source, a profitable industry may be established in the open waters of the gulf at this point. Continued experiments with the aim of discovering some method of avoiding the above mentioned menace to the plants, are in progress at the station; but it is as yet too early to hazard any opinion as to their probable results.

FOOD CONDITIONS IN CALCASIEU PASS AND THE GULF.

The food conditions in the pass as shown by the number of diatoms in the water, and also by the number in the stomachs of oysters from the different reefs, were very unstable

during the period of freshet in the early part of the season. On many occasions no diatoms were found in the water, while the stomachs of oysters taken at the same time as the sample of water, contained only the empty valves of diatoms and only a small number of these. The oysters on the jetties and those found on the buoy in the gulf, had a much more abundant food supply during this season, and the result was evidenced in their superior condition. In March and April of the present year the conditions prevailing in the pass and gulf were such as may be considered normal for these waters, so that satisfactory determinations of the food supply could be made. The food of oysters in these waters, as is also true for other parts of the State where I have had opportunity to make examinations, is made up chiefly of five species of diatoms. These are in the order of their abundance: Coccinodiscus perforatus (sp?), Eupodiscus radiatus, Melorsira sp., Navicula sp., and Pleurosigma spenceri. The first mentioned form was, with few exceptions, by far the most abundant, and sometimes constituted almost the entire stomach contents of the oysters.

FOOD RECORDS.

The food contents of the water and the number of diatoms in the stomachs of the oysters were determined in the usual manner by use of the rafter cell. One litre of water and the stomach contents of three medium sized oysters being used for each determination.

TABLE NO. 6.

Date.	Source of oyster and water	Diatoms in one litre of water.	Diatoms in oyster.
May 10, '05,	"Light House" reef....	100.	1,583.
May 15, '05	"Light House" reef....	0.0	2,875.
May 20, '05,	"Light House" reef....	1,728.	2,561.
May 25, '05,	"Light House" reef....	3,297.	5,681.
June 8, '05,	"Light House" reef....	19,345.	18,728.
June 15, '05,	"Light House" reef....	16,628.	17,956.
June 22, '05,	"Light House" reef....	13,728.	16,796.

TABLE No. 6—Continued.

Date.	Source of oyster and water.	Diatoms in one litre of water.	Diatoms in oyster.
May 10, '05,	Jetties................	5,284.	10,728.
May 15, '05,	Jetties................	10,448.	1,814.
May 20, '05,	Jetties................	3,763.	5,681.
May 25, '05,	Jetties................	16,628.	15,557.
June 8, '05,	Jetties................	19,947.	20,743.
June 15, '05,	Jetties................	17,792.	19,744.
June 22, '05,	Jetties................	14,248	18,393.
May 15, '05,	Reef 1-4 mil. below Leesberg	0.0	empty shells only.
May 20, '05,	Reef 1-4 mi. below Leesberg	0.0	1,795.
May 25, '05,	Reef 1-4 mi. below Leesberg	3,998.	5,203.
June 8, '05,	Reef 1-4 mi. below Leesberg	16,334.	15,276.
June 15, '05,	Reef 1-4 mi. below Leesberg	14,897.	13,822.
June 15, '05,	Reef 1-4 mi. below Leesberg	7,686.	10,097.
June 15, '05,	Buoy in gulf............	18,339	17,992.
June 24, '05,	Buoy in gulf..........	17,429.	18.964.

The figures given in the following table are averages of all the determinations made during March and April, 1906.

Date.	Locality.	Diatoms in one litre of water.	Diatoms in stomach of one oyster.
April,	"L. H. Reef"........	16,787	18,296.
May,	"L. H. Reef"........	18,904	17,998.
March,	Jetties..............	19,072	20,698.
April,	Jetties................	20,173	18,265.
March,	Reef 1-4 mi. below Leesberg	16,987.	15,896.
April,	Reef 1-4 mi. below Leesberg	18,584.	19,794.

Gulf Biologic Station,
Cameron, La.,
April 14, 1906.

A Preliminary Report

ON THE

Distribution of the Scallops and Clams in the Chandeleur Island Regions, Louisiana.

By M. H. SPAULDING.

I. INTRODUCTION.

During the summer of 1904, Dr. James L. Kellogg, then studying the oyster conditions at Cameron, visited the oyster grounds of St. Bernard parish as the guest of the Louisiana Oyster Commission. While in those waters he made a flying trip to the Chandeleur Islands where he discovered the occurrence of the small scollop (*Pecten irradians*) and the "little neck clam" (*Venus mercenaria*), both of which are valuable food forms in the New England States.

As Dr. Kellogg was unable to complete the investigation this winter as planned, I was engaged to determine the distribution and abundance of these mollusks in this region. In this connection it is a great pleasure to acknowledge Prof. Guilbeau's cordial co-operation with every stage of the work. I wish also to express my heartiest thanks to Captain William Heinemann and Captain W. F. Streckert, the keeper and assistant keeper respectively of the Chandeleur Light, for the many courtesies which they have shown the party while we have been working in these waters. I am also greatly indebted to Mr. L. R. Cary, Field Zoologist of the Station, with whom I was associated during the greater part of the cruise.

The station schooner "America" was placed at our disposal and was brought to Gulfport, Miss., by Mr. Cary and party, where I joined them in the latter part of January, when active work was commenced. An examination of nearly all the available bottoms in this region has been made, the results of which are given in the following report:

II. DESCRIPTION OF THE ISLANDS.

The islands in the Chandeleur region form a crescent-shaped chain nearly forty-five miles long, lying twenty-five miles southeast from Gulfport, Miss. Several smaller islands lying west of the main chain were also visited. The crescent, which extends in a general direction north and south, lies about twenty miles east of the marsh lands of St. Bernard Parish, and includes the following islands: Chandeleur, Errol and Breton. The small islands lying to the westward are North Harbor, New Harbor, Freemason and Old Harbor Islands.

Chandeleur Island is the largest and most important of the group. It is a low, narrow island, varying from about one hundred yards to over a mile in width, and about thirty-five miles long. Near the eastern side is a low sand ridge, raised in places into mounds less than twenty-five feet high. The island west of this ridge is lower and covered with a growth of coarse grasses and low bushes. This "marsh," which contains many small water holes, is more or less cut up by narrow, usually shallow bayous. The island consequently has the appearance from this side of being a chain of small grassy islets. In reality the eastern ridge is continuous throughout nearly its entire length. About a mile from the north end the Chandeleur lighthouse is located, and two or three miles below this are two groups of abandoned buildings, formerly the United States Quarantine Station. No other buildings are found on any of the islands.

From the eastern shore, which is exposed to the open gulf, the bottom deepens rapidly, but on the protected western side a wide shallow flat extends for upwards of a mile and a half. This flat is protected from water on the inside channel by a sandy ridge (or bar) which is almost uncovered at low tide. Gaps occur in this bar at several places, which enable shallow draught boats to pass over and anchor in the quiet water inside. The inclosed flat, covered with from three to seven feet of water in the deeper portions, shoals gradually to the shore. The bottom is a soft, slightly sticky mud, almost entirely covered with eel grass and algae. Close to the marsh the character of

the bottom is extremely variable, and will be discussed in more detail in connection with the various beds.

Errol Island, which is next in size, lies about four miles to the southward. About eight miles long and almost everywhere less than one-half mile in width, it is very similar to the island already described. Along the eastern shore a low ridge of sand, four or five feet high, has been thrown up by the waves, but it is nearly uniform in height and is without the high mounds characteristic of the other island. The western side is a low, marshy flat, which is somewhat higher and less cut up in the lower portion of the island, although it is probably entirely covered during an extreme high tide. From the marsh on this side the bottom continues as a wide shallow flat, which is also protected by a bar. Near the northern end the flat is almost entirely a very shallow sand spit, while the remainder is nearly all soft bottom, with irregular patches of hard sand near the shore. The soft bottom is unevenly covered with eel grass at a depth of from two to five feet. The southern point of the island continues as a shallow spit for some distance.

Breton Island, which forms the southern end of the crescent, is a hook-shaped island about six miles long, separated from Errol Island by a gap eight miles wide. In general it is very similar to the islands already referred to, and does not require any detailed description in this connection. The opening between the points is more or less protected by a shallow bar similar to those which limited the flat at the other islands. The area enclosed in this manner by the island is nearly all soft bottom, as was found at the other islands. The shallower portions are almost entirely covered with eel grass. Several small, grassy knolls protrude from the water near the middle of the island. Around the edges of these, as well as in several of the narrow bayous on shore, many fish were seen, among which the redfish and the common mullet were the only food fish recognized.

The New Harbor Islands are three low, grassy islets, lying about fifteen miles below the lighthouse, and separated from the main island by a channel about three miles wide. From these islets a broad flat extends in a southwesterly direction for over a mile.

The North Harbor Islands, lying about two miles north of the preceeding group, form a long, narrow crescent extending nearly at right angles to the main chain. From the southern side extends a broad flat, which is similar to and in part connected with that of the New Harbor Islands. At the north point a large clam bank, which is shown on the chart, has entirely disappeared. The southwestern point is continued into an extensive flat, slightly different from the other flats already referred to, in that it is almost entirely clean sand, with practically no eel grass upon it.

The Freeemason Islands are separated from this point by a channel about a mile and a half wide. Charted as four islands, there are at present only three important ones, the change which has taken place being indicated on the accompanying chart by heavy stippling. Along the eastern side of the group is a wide barren flat, which is continued for about a mile below the southern point. The Old Harbor Island is a low spit of broken shells and coarse sand lying in a southwesterly direction from the Freemasons, and contains nothing connected with the present report. Many fish were seen in the deep holes close to the spit, and should be a profitable fishing ground during some seasons of the year.

III. DESCRIPTION AND HABITS OF THE SCALLOP.

The scallop *(Pectens irradians)* found in this region is extensively fished in the waters of Massachusetts and adjoining States, where it is considered a great delicacy. In referring to the food value of the scallop, Dr. Hugh M. Smith, in his report on the giant scallop fishery of Maine, says: "Scallops in general have always been highly esteemed for their edible qualities, and in many localities are regarded as among the choicest products of the water. Unfortunately, the usual retail prices are so high that the great mass of the people have never been permitted to partake of this luscious food."* An analysis of the comparative food values of the different edible molluscs, quoted in the same report, places the scallop at the head of the list in the possession of the highest percentage of nutrient material, outclassing even the oyster in this respect.

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* The Giant Scallop Fishing of Maine, Bull. U. S. F. C., Vol. IX, 1883, p. 333.

The shell, about three inches high, is equilateral, and has deep crenations extending from the apex to the margin. The valves are equal in size, the lower (right) slightly more arched than the upper. The hinge margin is broad, nearly straight, with equal ears. A shallow byssal notch at the base of the anterior ear on the right valve is deeper and more pronounced in the young specimens than in the adult. The shell varies in color from pale straw to reddish orange or dark brown. The upper valve is usually covered with a mat of fine algae, silt and worm tubes, which aid materially in concealing the scallop as it lies on the bottom among the blades of eel grass.

The following description of the scallop by Dr. Sterns is given by Dr. Smith in the report already referred to: "The enamel of the fan shell is exceedingly beautiful. The mantle, or thin outer edge, which is the part nearest the rim or edges of the valves, conforms to the internal structure of the latter, and presents the appearance of a delicately pointed ruffle or frill. This mantle is a thin and almost transparent membrane, adorned with a delicate fringe of slender thread-like processes or filaments, and furnished with glands which secrete a coloring matter of the same tint as the shell. The valves increase in size in harmony with the growth of the soft parts by the deposition around and upon the edges of membranous matter from the fringed edge of the mantle which secretes it. This cover is also adorned with a row of conspicuous round black eyes around its base. The lungs or gills are between the two folds of the mantle, composed of fibers pointing outward, of delicate form and free at their outer edges so as to float loosely in the water. The mouth is placed between the two innermost gills, where they unite. It is a simple orifice, destitute of teeth, but with four membranous lips on each side of the aperture. The mechanism by which respiration and nutrition are secured is elaborate and exceedingly interesting. The filaments of the gill fringe, when examined under a powerful microscope, are seen to be covered with numberless minute hair-like processes, endowed with the power of rapid motion. These are called *cilia*, and when the animal is alive and *in situ*, with the valves gaping, may be seen in constant vibration in the water, generating by

their mutual action a system of currents by which the surface of the gills is diverting toward the mouth animalcules and other small nutritious particles."*

The adult scallops are found scattered about on the eel grass beds, more or less hidden by the blades of grass. Usually lying on the right valve, the left is more or less concealed by the fine growth, sediment and worm tubes which cover it. Occasionally many will be seen turned up on the edge of the shell, the light mantle edges, with their conspicuous eye spots, causing them to stand out in sharp contrast to the surrounding dark bottom. Others drew attention to themselves by the sudden closure of the shell, causing a movement of the water.

Probably of all the economic bivalves the scallop is the only one capable of swimming through the water. This is accomplished by a sudden contraction of the powerful shell muscle, which brings the valves together with a snap. The water held between the valves is forced out in a jet, which gives the scallop a backward impulse. This irregular movement is rapidly repeated, and the resulting movement is called *dancing.* In the Northern States large schools of scallops are sometimes seen migrating from one bed to another, but the extent of their movements is unknown.

While the adults are unattached the young, after passing through a short, free-swimming stage on hatching from the egg, sink to the bottom and attach themselves by means of a byssus to blades of grass, shells or other convenient objects. The byssus is a strong holdfast of slender, tough fibers, secreted by glands in the rudimentary foot, and is used by other bivalves as a means of attachment. By attaching itself in this manner the young scallop is to a certain extent protected from injury and is guarded against the danger of being buried in the soft mud, as would undoubtedly be the case if it settled immediately to the bottom. Not many young were found at this time, and of these the smallest was about one-eighth of an inch long. On this account it was impossible to ascertain at what size they first attach themselves, or how long they remain attached. Specimens about one inch long have been found fastened to the

* Bull. U. S. F. C., Vol. IX, 1883, p. 315.

grass, while other individuals but little longer have been seen unattached. It is probable that when about one to one and a half inches long they free themselves and pass the remainder of their life unattached.

Of the soft body only the large adductor muscle of the shell, which is called the "eye" or "heart," is used as food, the catch usually being shucked before being placed on the market. In this species this muscle is about one inch long and half an inch in diameter. The remainder of the body is either thrown away or used as bait.

Reference has already been made to the high price which this form commands. Unfortunately, no statistics later than 1889 are at my disposal at present, but at that time the Rhode Island fishermen received 75 cents to $1.00 per gallon for their catch. It is very probable that should the scallop be introduced into the local market, where it is at present unknown, a ready demand for all that these beds could supply would soon be created, resulting in a profitable industry.

IV. DESCRIPTION AND HABITS OF THE CLAM.

As has already been said, the clam which is found in this region is a northern form known under the names of "hard," "little neck" clam, or "quahog" *(Venus mercenaria)*. The shell is rounded, with the posterior end slightly prolonged, and has a pronounced notch in front of the umbo. It is heavy, nearly one-quarter of an inch in thickness, and the only markings are the more or less pronounced concentric ridges showing periods of growth. The largest specimens which we have found in this region have been about six inches long, although the average would be much smaller.

As the name "little neck" implies, the siphon or "neck" is very short, and the clams are found either only partially buried in the sand or else with the posterior end of the shell barely showing at the surface. In any case the hinge (or back of the shell) is always uppermost. They are found on almost any kind of suitable bottom which is neither too soft to allow them to stay at the surface nor so shifting that they are unable to hold their position. As will be shown more completely

later, a slightly soft and tenacious bottom with a limited growth of vegetation apparently offers the best conditions for them in this region.

The food of the clam is similar to that of the oyster and scallop, namely, diatoms and other microscopic organisms, while feeding a constant flow of water takes place through the mantle chamber, the water entering through one siphon tube and passing out the other. As it circulates through this chamber it bathes the surface of the body and gills, which are covered with microscopic, thread-like cilia, which beat constantly in a given direction. By their movements they aid in keeping up the current of water and also carry the food particles, which come in contact with them to the mouth.

No very small clams were found alive at this time, and only a few small shells were picked up on the shore at one point.

It is also notable that on any particular bed the clams are of nearly uniform size instead of being several different sizes, as would be expected. For instance, at bed No. VIII. the clams are all of approximate maximum size (six inches long), while on several beds(especially 4 and 6) they are only about half that size. It is very probable that a study of the conditions during the breeding season would give a clue to the reasons for this, and might also make it possible to explain the limited number of clams found on most of the beds, none of which are stocked with anything like the numbers which they should support.

V. ENEMIES.

While numbers of dead shells of both forms have been found scattered over the various beds, in most cases it has been impossible to determine the destructive agent. Two species of conch (*Fulgur perversa and F. pyrum*) are rather common on the flats, and several other small gastropods are also abundant. Clams partly devoured by the larger species of conch (*F. perversa*) have been found by the lighthouse keeper, but I have never seen them being destroyed. Numbers of clam shells have been found with the edge of one valve chipped away, leaving a small hole, and it is possible that some one of their enemies has attacked them in this manner. Sud-

den storms by shifting the bottom would undoubtedly bury numbers of clams if not sweep entire beds away (as is suggested in connection with No. VII.). It is also probable that many of the scallop shells found on the sand flats were destroyed in this manner.

V. DESCRIPTION OF SCALLOP BEDS.

While a general description of the flat on which the scallops are found has already been given, it will be necessary to refer more explicitly to some of the areas where they are most abundant.

1. On the flat below the lighthouse the "eel" grass covers the bottom almost completely for about two miles. South of this point several sand spits break up the grassy bottom. Over this grassy area of about one square mile, scallops are fairly abundant at a depth of from two to four feet. At the lower end, near the sand spits, they were less numerous, although many dead shells with hinge ligament intact were seen washed up on the spits.

2. About eight miles below the lower end of this bed, scallops are very abundant on the flat for a distance of about six miles. The bed here averages three-quarters of a mile in width and covers about four and a half square miles.

3. South of clam bed No. IV. the flat for about one and a half miles was very thickly covered with scallops. Close to the clam spit they were apparently more abundant than at any other place we visited. This was probably due to the fact that we were able to wade around and "tread" them out instead of depending on seeing them from the skiff. Probably had we been able to search for them in the same manner at the other beds they would have proved equally abundant. A short distance below the island no live scallops were found, but the numbers of dead shells seen on the sand flat near the edge of the water indicated that they were abundant near by. This area, with an approximate area of one square mile, would undoubtedly prove to be larger at other seasons of the year..

Near the lower end of the island the "eel" grass bottom was very abundant, but few live scallops were seen on the brief visit made there.

4. The flat along the lower part of Errol Island has already been referred to. About three miles below the northern end of the island it is about a mile in width, narrowing gradually to one-half at the lower end. As has already been said, "eel" grass is rather irregularly distributed over the entire flat, covering about sixteen hundred acres. While very few scallops were found here, a few young were present, attached to the grass, and the older individuals might have been missed, as the water was too roily to see the bottom. An examination of this area under more favorable conditions would, very probably, show more promising results.

5. The conditions at Breton Island are very similar to those at Errol Island, and only a few scallops were found in different parts of the flat which covers about three square miles. The water here, as at Errol, was too roily to permit the scallops to be seen, so numbers must necessarily have been overlooked.

6. The flat surrounding the North Harbor Islands has an area of about three square miles, the most of which is covered with "eel" grass. While no living scallops were found at this time, dead shells were not uncommon, and it is probable that if they are not found here at other seasons in the year it would be possible to stock it artificially with good results. The flat at the Freemason Islands contains practically no "eel" grass bottom, and while a few growing scallops were found attached to the fine growth, it is probable that they were carried there from neighboring beds of the New and North Harbor group.

These beds cover a total area of about ten square miles. In estimating the beds only the most abundant areas have been noted. Very probably a study of conditions during the spawning season would show a greater area to be productive. It is probable that artificial fertilization would prove an effective means of increasing the productiveness as well as the area of the beds. In this manner nearly the entire flat along these islands with an area of about forty square miles could be made productive beds.

VII. DESCRIPTION OF CLAM BEDS.

1. Near the lighthouse there are several rather extensive sand spits on which the clams are said to be most abundant

during the late fall and winter, almost entirely disappearing during the summer. While most numerous on the sandy shoals, they are not entirely confined to the open bottom, but are found quite often amongst the "eel" grass, occasionally out as far as four or five feet of water. These spits have an estimated area of from ten to fifteen acres.

2. About three-quarters of a mile below the lower quarantine station the island becomes a broad sand flat, nearly two miles long. On the inner side this continues into the water as a shoal pit. During extreme high water the entire flat is covered, as is shown by the number of dead shells which are washed upon the center of the island. Along the low water line clams are fairly abundant, particularly about the middle of the flat. They are, however, confined to a narrow strip near the low tide mark and do not extend out on the spit for any great distance. Approximating the bed as six feet wide and a mile in length, it would have an area of about three-quarters of an acre.

3. Nearly ten miles south of this bed the island is cut up by many bayous, the entrances to which are almost completely blocked by a shallow flat of extremely tenacious, black, sandy clay, which extends nearly half a mile from shore and about a mile in length. The bottom is more or less covered with a fine grass. Throughout nearly the entire flat, clams are very abundant, although they were nearly all about two and a half inches long. This bed has an area of about three hundred and twenty acres.

4. About two miles south of this bed there is a small inlet lying a short distance from the main island with which it is connected by a shallow sand and mud flat. The lower end of this island is continued as a sand spit nearly a mile long and about a quarter of a mile wide. At the lower end this spit is composed of a rather hard mixture of sand, clay and mud, but near the island the bottom is very soft. No clams are found on it. Along the northern side of the spit and continuing in the hard bottom around the upper side of the island, and for nearly a mile along the main island, clams are very abundant, though very few large ones were found, covering about one hundred and eighty acres, and, while most numerous near

the north side of the spit, were by no means confined to that side, but scattered over the whole spit.

5. At several places south of this islet a very few clams were found in small clusters, but at no place was there any large bed. The spots are indicated on the chart, and, very probably, these places could be made more productive by artificial means. No estimate was made of these points, but they would probably equal bed No. 4 in area.

6. Mention has already been made of the flat near the New Harbor Island. Along the western shore of the largest of these islets, the bottom is an extremely soft mud. About ten yards from shore this becomes firmer and is more or less evenly covered with short, fine grass. Here clams are very abundant the entire length of the islet, extending out into four or five feet of water (at low tide) with very little diminution in numbers. These clams are nearly all of a uniform size (two and a half inches long) and cover about sixty to seventy acres.

7. Attention has been called to the large clam bank shown on the chart a short distance from the north point of North Harbor Island. Several careful attempts were made to locate this bank at different times, but all failed to show any indications of it. Instead of finding a shoal bank covered with from two to five feet of water all our sounding at this point gave a depth of from six to ten feet. On the shore abundant evidence is present, in the piles of dead shells, to indicate that a bed had been located here at some time in the past. It is very likely that the bed was washed away by some heavy storm. All these shells, however, were very badly weathered, and had evidently been on the beach for some time.

8. At the southwestern end of this group the topography has changed slightly since the survey was made. At present the terminal islet is separated from the rest of the chain by a channel about a mile wide, instead of being continuous with the adjacent island, as shown in the chart. Below the lower end of this islet a broad flat extends for over a mile. The water deepens very gradually, and the three-foot line is about a mile from the island. The bottom is a rather hard, dark sand, covered with irregular grassy patches, while a few are found

outside the weed patches, they are never present in any numbers. It is probable that this growth serves to keep the bottom from shifting, and so protects the clams. Although the clams are by far more abundant at the southern end, where they extend out to nearly five feet of water, they are by no means limited to that portion of the flat, but extend northward along almost the entire eastern shore. This bed covers an area of about one square mile, and clams are very abundant on it. The average size is very large (about five and a half inches) no smaller ones having been seen. At the northern end, dead shells piled up on the shore and scattered over the bottom for some distance probably are the remains of some former bed which was destroyed when the channel was cut through, as no live clams in any numbers were seen at the point.

At the lower point of the adjacent island belonging to this group, a few live clams and many dead shells were seen scattered over the flat, but no very great area was covered by them.

9. The western islands in the Freemason group are connected by a shallow bar of hard sand which covers about sixty acres. On this bar many large clams are scattered about, the majority in good condition. A few dead ones were found in which the soft body had not entirely disappeared.

10. The southern point of the lower island is continued into the long spit, on which were many dead shells, but no live ones could be found. Nearly all these shells were with the hinge ligament intact, showing that they had died or been killed but recently. This flat, if productive, would have an area of about one hundred and sixty acres.

11. Reference has been made to the sand flat near the northern end of Errol Island. On this shallow spit, which covers nearly 160 acres, dead shells were fairly abundant, the majority with one valve broken across the middle, as if it had been struck with a hammer or crushed by some powerful force. No live specimens were found on the small spits near the shore, and a few live ones were occasionally seen on the edges of the "eel" grass patches, but never in any abundance. These beds, with a total of about three miles, by no means represent the total of the available bottom.

At this time of the year we are subjected to unfavorable weather conditions at times, which, combined with the limited period at our disposition, has compelled us to devote most of our energy to the examination of the territory, and we have therefore been obliged to leave several important points untouched. Other questions, equally, if not more vitally concerned in their influence on the extent and productiveness of the beds, have been impossible to investigate at this season of the year.

Probably the most important of these is the study of the conditions during spawning season, which probably takes place during the summer and fall. It is at this most critical period in their life history that external conditions exert the greatest influence in limiting the productiveness of the beds. A sudden change in the temperature or salinity of the water would, undoubtedly, cause great havoc among the young. Enemies are also able to destroy countless numbers of the young forms before they become old and strong enough to withstand these attacks.

Situated as these islands are, but a short distance from the mouth of a mighty river like the Mississippi, discharging immense volumes of fresh water into the gulf, any change in the direction of the wind affects the salinity of the water, and at the same time the amount of food material carried in suspension. The influence of these changes on the clams and scallops should be studied before any definite conclusions can be drawn.

It is impossible at this time to more than call attention to the work which is being done elsewhere along these same lines. Important experiments have been made with the soft clam (*Mya arenaria*) by Dr. Kellogg and other investigators, which prove that it is possible to stock barren areas by artificial bedding with productive results. Experiments of this nature in this region would undoubtedly give beneficial results.

In conclusion, it is strongly recommended that provisions be made for the completion of the investigation of this region, especially during the breeding season. The study would very probably show the areas of these forms to be much larger than at present estimated, as well as being more productive.

SUMMARY.

The results of the examination of this region are:

1. The scallop (*Pecten irradians*) is scattered irregularly over the available territory of forty square miles, but is abundant only about ten miles of this area. Undoubtedly if introduced into the local market it would be readily appreciated for its delicate flavor and would become a valuable addition to the food mollusks of Louisiana.

2. The clam (*Venus mercenaria*) covers about three square miles and could be greatly increased in number and territory extended by the use of artificial propagation.

3. Attention is again called to the need for further study of these beds during the breeding season before the conditions and resources can be thoroughly understood.

Gulf Biologic Station Laboratory,
Cameron, La.,
May 1, 1906.

Chart
of the
Chandeleur Island Region
Louisiana.
Showing the location of the CLAM and SCALLOP Beds.
from
U S Coast Charts No: 190 and 192
North Harbor Ids
New Harbor
Old Harbor Ids
1
2
3
4
5

A Preliminary Report

ON THE

Oysters of Chandeleur Sound

By L. R. CARY.

The observations recorded in this report were made during the latter part of January and in Febuary of 1906.

As the primary object of the trip to this region was to make investigations relating to the study of the clam and scallop in the waters about the Chandeleur Islands, the area covered in the course of the oyster work was necessarily limited to the waters near these islands, and did not include the important oyster fields lying at the western border of Chandeleur Sound, in the Parish of St. Bernard.

Over all of that part of the sound visited on this trip, the bottom was made up of hard, clean sand that would afford no stable place of attachment for oysters; and, besides, during the entire period of my stay in the region the water in that part of the sound was always by far too salt to allow of the growth of good oysters. The salinity of the water was from 1.023 to 1.027 during this time, and while oysters are very adaptable to wide changes of salinity in the water in which they live, when the salinity reaches as high a point as that just mentioned the oysters growing in those waters are certain to be in the poorest condition if they continue to live.

Many empty shells were found cast up on the beach at several places on the island, but no living oysters were taken from the surrounding waters. On the northern shore of the "North Islands" there is a huge bank of oyster shells four or five feet in thickness, and extending out into the water from this point, the bottom for a half mile or more ~~being~~ is thickly covered with empty oyster shells. Many of the shells were taken up from the old reef, but not a single living oyster was found

among them. The shells were all separated and the hinges entirely disintegrated, in every case showing that the oysters had been dead for a number of years.

The presence of these shells may be accounted for in part by some facts given in an article, "The Oyster in Louisiana," by John Dymond, Jr., which appeared in the first biennial report of the Oyster Commission of Louisiana. Mr. Dymond says, page 89: "For instance, the water from the Nita crevasse killed all the oysters in the parish of St. Bernard. The point of proper mixture of fresh and salt water was, by this excess of fresh water, extended or pushed much farther into the salt water of Chandeleur Sound, and at this new point of proper mixture oysters were, at once found to begin to grow. When the crevasse was closed the old conditions gradually established themselves; the oysters in the sea were in time impoverished or made thin and of little value by the excess of salt water, and the oysters grew again on the old shells and reefs in St. Bernard. The proper line of water mixture gradually moving backward to the shore."

OYSTERS AT THE CHANDELEUR ISLANDS.

The Chandeleur Islands, throughout their entire length of thirty-five miles consist of a narrow sand spit, with a hard beach on the east side, which is exposed to the open gulf. On the west side, except for a few places where the entire width of the island is below the level of very high tides, there is a strip of marsh varying in width from one hundred yards to more than two miles. This marshy area is cut up by a great number of small inlets, or bayous, running in from the shallow flats on the west side of the islands, while the surface of the marsh is dotted with shallow pools varying in size from those having an area of not more than a couple of square yards to some several acres in extent. Most of the inlets have a high sand bar at their mouths so that at low tide they were cut off from the sound, while inside the bar the water is from a few inches to ten feet in depth. The bottom of the pools is composed of soft, deep mud, and is in most cases devoid of any vegetation. Only a few of these pools have direct communication with the bayous except in time of storms when the whole marsh is flooded, so that the

water in them is influenced very markedly by the rains, and was at the time when these observations were made, much fresher than the water in the sound and in the bayous. The salinity of the water in these pools varied from 1.000, in the case of a pool near the lighthouse at the north end of the islands, to 1.022 in some of the pools where the surrounding marsh was very low and an overflow from the sound most to be expected. The pools at the north end of the islands are on higher ground than the others and the water in these is said to be fresh all the time. Oysters were found growing in almost all of the pools in the marsh in greater or less numbers, and many clusters of elongated "coony" oysters were found in the marsh along the banks of the inlets where they were above the water most of the time. In the pools the oysters were usually arranged in clusters attached to an empty shell that was buried deep in the mud, but in almost every pool a few large single oysters were found, either lying on the surface of the mud or buried deeply with only the open ends of their shells projecting above the bottom. Many of these single oysters were from seven to ten inches long and well rounded.

Whatever hard body had served as an attachment for the spat when these oysters settled down had long since disintegrated and left no trace of itself on the shell. Many broken stems of the sedges that grow about the pools were floating on its surface, and it is probable that these may serve as an attachment for spat at the breeding season. Such woody stems when submerged in the water would persist for a sufficient time for the young oysters to have attained a size large enough to make it certain that they would be in no danger of settling into the mud and becoming covered up. A material of this kind would make an ideal spat collector, as the liberation of the oysters from the danger of crowding is assured, and only well rounded individuals could result from the use of such a form of clutch.

The clusters in the pools bear a dense growth of young oysters, and wherever any hard body was found on the bottom there were always a large number of young attached to it.

The oysters making up the clusters on the banks of the inlets were much smaller than those found in the pools, and

they were also more densely crowded and misshapened. No large single oysters were found among these clusters, although the surrounding bottom was as firm as that in the pools.

The supply of food organism in the water, both in the pools and in the more saline water of the inlets, was very abundant. The condition of the oysters in all the pools, and more especially in those near the north end of the islands, was exceptionally good. The "coon" oysters along the banks of the inlets were in good condition, but on account of their small size were practically worthless.

In several of the bayous about midway of the chain of islands, where the marsh is widest, small reefs of oysters were found in from three to five feet of water. These reefs were all at the inner ends of the bayous deep in the marsh where the water was considerably less saline than near their mouths. The oysters on these reefs were densely crowded and in poor condition as compared with those taken from the pools in the same locality.

Although limited to small areas in any one place the total area of oyster producing bottom in the marshes at the Chandeleur Islands makes in the aggregate a good many acres, and, as is shown by the size and quality of the single oysters growing in the pools, the conditions are very favorable for the production of excellent oysters. The absence of any material to serve as clutch, other than the few shells of the parent oysters, is the chief cause of the small number of oysters found in most of the pools. That the supply of food organisms is sufficient to support many more than are present in most cases is shown by the fact that in some of the pools the entire bottom is covered with dense clusters, and yet the oysters were in good condition while counts of the diatoms, both in the stomachs of the oysters and in the water about them, showed the available food supply to be sufficient to assure its continued abundance.

The consistency of the bottom is such that there is no danger of even small shells sinking below the surface, so that only a small amount of clutch would be necessary in order to establish permanent beds in any of the pools. The water in all the pools is so shallow that the oysters could be gathered very easily, and

all parts of the marsh are accessible by way of the many bayous that come into it from the sound.

The oysters living along the banks of the inlets near high water mark could be greatly improved by breaking up the clusters and giving each one an opportunity to grow to its normal shape; however, as the oysters in these places are always of poorer quality than those in the pools, it would seem advisable to transfer them to the pools where the physical and biological conditions are more favorable for their development.

While no very extensive oyster industry could be built up at this point because of the limited area, even under the present conditions the natural oysters could be worked with profit, while if cultural methods were used, the output would reach a size that would assure profitable employment for a number of men. The quality of the oysters during the marketing season is exceptionally fine, and I am told that they become fat early in the season, so that the best prices would be obtained for the product of the beds.

Although the islands are twenty-five miles from the mainland, the distance from a market or shipping point is no greater than that traveled by many of the oystermen working on the inshore beds in order to market their catch, and the absence of any canals or narrow streams makes the time consumed in a trip less than it is in many instances where the distance is nearly the same.

Gulf Biologic Station Laboratory,
Cameron, La.,
April 14, 1906.

A Contribution

TO THE

Fauna of the Coast of Louisiana

By L. R. CARY.

The following list contains a record of the animals (with the exception of the *Protozoa and Insecta*) collected by the station staff during the past three seasons. Collections have been made at Cameron, in Vermilion Parish, near Southwest Pass, and at the Chandeleur Islands. Records were kept of the forms observed at several other places on the coast. No systematic collecting was done at other than the three points mentioned above.

A list of the Protozoa from Cameron by J. C. Smith and a list of the Insecta by Jas. S. Hine was published in the station bulletin No. 2, issued in May, 1904. This issue of the bulletin contains a further contribution to the insect fauna by the same author.

Many of the specimens listed from Cameron and a few from the Chandeleur Islands were collected by Dr. Cowles during the season of 1904, the remainder of those from Cameron and other points were collected by the writer during the past year.

The Mollusca and Crustacea were identified by members of the staff of the United States National Museum, at Washington, D. C.

Specimens of all the forms listed, as well as others as yet undetermined, are preserved in the museum collection at the Gulf Biologic Station.

PORIFERA.

Clion~~e~~a sulphurea—This boring sponge is common on the shells of living oysters, as well as on dead and broken shells, all along the coast.

COELENTERATA.

Hydactinea echinata—Found abundantly on piles and rocks of the jetties at Cameron; also abundant on oysters from many points on the coast.

Siphonophora—*Physalia arethusa*: The "Portugese man of war" occurs abundantly during the summer months in the waters of the gulf.

Scyphomedusae—*Ciropsalmus quadrumanus;* found four or five miles off shore from Calcasieu Pass in large numbers during August and September.

Stomolophus meleagris; fully grown specimens are present in the waters of the gulf during all seasons, while during August and September the young are seen in dense masses covering the surface of the water.

Chrysaoa sp.; taken while dredging in twelve to eighteen feet of water off Calcasieu Pass.

Anthozoa—*Renilla reniformis;* a few specimens found on the beach at Cameron; abundant on the beach at the Chandeleur Islands.

Leptogordia virgulata; rarely found at Cameron.

Gorgonia sp.; found attached to mollusk shells at Cameron, off Southwest Pass (Vermilion Parish), and at the Chandeleur Islands.

Actiniaria—*Anthopleura cavernata;* common on the rocks of the jetties at Cameron.

Calliactis tricolor; on gastropod shells, inhabited by hermit crabs from Cameron and the Chandeleurs.

Aiptasia pallide; abundant on the jetties at Cameron.

Ammophilactis rapiformis; found in large numbers on the beach at Cameron after storms.

Cerianthus americanus; the tubes of this actinian were found in the flats at the mouths of bayous that cut up the marsh on the east side of the Chandeleur Islands.

Note—After a severe storm in May, 1905, a large Bunodid and three specimens of an Edwardsian were found on the beach at Cameron, but all of these were too badly mutilated to be identified.

ECHINODERMATA.

Asteroidea—*Luidea clathrata;* this form has been taken while dredging at Cameron in twelve to eighteen feet of water, and was found in abundance on the beach at the Chandeleur Islands.

Echinoidea—*Mellita testudinata;* occurs abundantly in the shallow waters about the Chandeleur Islands.

Mocra atropus; after blows from the east or south the beach on the outside of the Chandeleur Islands was covered with the empty tests of this form.

Ophiuroidea—*Ophiura brevispina;* found in large numbers among the eel grass in shallow water on the west side of the Chandeleur Islands.

Holothuroidea—*Thyone briarius;* a few specimens of this form have been found on the beach at Cameron after heavy storms.

PLATYHELMINTHES.

Turbellaria—*Planaria sp.;* a small planarian is very abundant on grass and weeds growing in the fresh water ponds about the station.

Leptoplana sp.

Bdelloura candida; this form occurs as an ecto-parasite attached to the limbs and book-gills of the king crab, Limulus polyphemus.

ANNELLIDA.

Nerics pelagica; found abundantly among oysters all along the coast.

Diopatra cuprea; the tubes of this annelid are abundant on the sand shoals near the mouth of Calcasieu Pass, and on sandy flats at the Chandeleur Islands.

Chaetopterus pergamentaceous; abundant on the flats at the Chandeleur Islands; the empty tubes are sometimes found on the beach at Cameron.

Arenicola sp.; a few specimens were found at the Chandeleur Islands.

Sabellaria vulgaris; very common on shells in shallow water all along the coast.

CRUSTACEA.

Cirrepedia—*Lepas anatifera.*

Lepas anserifera; both of these forms are found attached to wreckage and drift wood thrown up on the beach at Cameron after storms. ur

Balanus eb~~f~~*neus;* found on rocks, wharf piles and shells all along the coast.

Dichylaspis mulleri; this stalked barnacle is found attached to the gills of the common edible crab, Callinectes sapidus.

Decapoda—*Panaeus setiferus;* the large edible shrimp is common all along the Louisiana coast.

Palaemon tenuicornis; a small shrimp; is common along the coast.

Alpheus heterochelis; "pistol crab," common on the oyster reefs at Cameron.

Clibanarium vittatum: found inhabiting shells of Neverita and Purpura.

Cambarus clarki.

Cambarus heini; these two crawfish are abundant in the fresh water pools about Cameron.

Menippe nodoformis; the stone crab occurs in shallow water along the coast.

Callinectes sapidus: the southern edible crab, abundant along the whole gulf coast.

Ocypode albicans; found on the beach at Cameron.

Uca mordax; occurs in the marshes near salt water on all parts of the coast.

Petrolisthes armatus; found on the beach at Cameron among the "gulf" weed, which is washed up during storms.

Libin~~es~~*ia dubi*~~s~~*a;* common in shallow water along the coast. many specimens are found living beneath the bell of large Stomolophus.

Polyonix macrochelis; occurs as a commensal in the tubes of Chaetopterus.

Pinnixa chaetopteres; occurs as a commensal in the tubes of Chaetopterus.

Pinnotheres maculatus; occurs inside the mantle of Pinna seminuda and is found occasionally in Pecten irradiens.

Pinnotheres ostreum sp.; found in oysters at several points on the coast.

Panopeus herbstii; found on oyster reefs at several localities on the coast.

Arachnida—*Limulus polyphemus;* abundant in shallow water over sand flats at the Chandeleur Islands.

MOLLUSCA.

Cephalopoda—*Spirula australis;* the shells of this form are common on the beach at Cameron, and at the Chandeleur Islands.

Loligo bervis—This small squid is abundant in the waters about Cameron, and is frequently used as food by fishermen.

Gasteropoda—*Neritina reclivata;* abundant on the grassy shoals at the Chandeleus Islands.

Sigaretus perspectivus; a single specimen of this form was found at the Chandeleur Islands.

Crepidula plana; this form lives attached inside the empty shells of large gasteropods.

Crepidula convexa; found in large numbers attached to stones and large shells at several points on the coast.

Crepidula fornicata; common to the Chandeleur Islands attached to living scallops.

Solarium granulatum; a single specimen from the Chandeleur Islands.

Littorina irrorata; live specimens taken from several stations at the Chandeleur Islands, empty shells common on the beach at Cameron.

Cerithium muscarium; common at the Chandeleur Islands, having about the same range as Neritina.

Cerithiopsis sp.; this small form was found only on a red sponge living among the eel grass in shallow water at the Chandeleur Islands.

Modulus modulus.

Strombus pugulis; this beautifully colored shell was found in abundance at the Chandeleur Islands, and a few worn specimens are found occasionally on the beach at Cameron.

Dolium galea; a few specimens of this form were taken at the Chandeleur Islands.

Cassis inflata; live specimens and empty shells are abundant on the beach at the Chandeleur Islands.

Murex spinicostatus; found on the beach at the Chandeleur Islands, South West Pass, and at Cameron.

Murex pomum; a few badly worn specimens were taken on the beach at the Chandeleur Islands.

Eupleura caudata; a single specimen from the New Harbor Islands.

Purpura haemastoma var. floridana; this small snail is very abundant along the whole coast, its egg capsules are found on the rocks of jetties and on piles and buoys.

Anachis avera var. semiplicata; occurs on shallow flats over the entire coast, found feeding in large numbers on dead mollusks.

Nassa vibex; has about the same range and habits as Anachis.

Nassa acuta; taken on the beach at Cameron.

Tritonidea cancellaria; found on the beach at Cameron and the Chandeleur Islands.

Fulgur perversa; specimens of this form, from two to ten inches in length, are very abundant in the shallow waters all along the coast.

Fulgur pyrum; smaller than the preceding species, with which it is usually associated.

Fasciolaria tulipa; common at the Chandeleur Islands.

Oliva litterata; this beautifully colored shell is abundant at the Chandeleur Islands and a few well preserved specimens, besides many worn ones, are found on the beach at Cameron. These shells are taken at the Chandeleurs and sold to be used as charms, and other ornaments.

Terebra cinerea; a single specimen from the east beach at the Chandeleur Islands.

Cancellaria reticulata; common at the Chandeleur Islands.

Distortrix reticulata var. clathrata; a few specimens taken on the beach at the Chandeleur Islands.

Neverita duplicata; abundant all along the coast.

Aspyris lunata; from the grassy flats about the New Harbor Islands.

Ianthina fragilis; the shells and floating egg-masses of this mollusk were abundant at Cameron during the spring of 1905.

Bulla striata; in shallow water, New Harbor Islands.

Melampus flavus; abundant at the Chandeleur Islands, and at Cameron.

Succinea campestris; found in great numbers on the grass in all the marshes along the coast.

Helix fraturna; taken at Cameron in the summer of 1904.

Polygyra triodontoides; from the Chandeleur Islands (?) 1904.

Scaphopoda—*Dentalium gouldii;* empty shells found on the beach at Cameron.

Pelecypoda—*Leda concentrica;* taken in the dredge in twelve feet of water off Calcasieu Pass, the empty shells of this form are very abundant on the beach east of the jetties at Cameron.

Arca pexata; abundant at the Chandeleur Islands.

Scapharca campechensis; abundant in the shallow water near the gulf beach at Cameron.

Mytilus hamatus; taken on the east beach, Chandeleur Islands.

Modiola tulipa; occurs abundantly in shallow water in the marshes abount the Chandeleur Islands.

Modiola plicata var. semicostata; found in abundance over the whole Louisiana coast attached to stones, piles, and especially abundant among the densely crowded "coon" oysters.

Anomia glabra; common among oysters at Cameron.

Anomia simplex; found attached to living scallops at the Chandeleur Islands.

Pinna muricata; abundant on the flats on the east side of the Chandeleur Islands. Most of the specimens of this large lamellibranch contained a greater or less number of small black pearls, as many as eighteen being found in a single specimen.

Pinna seminuda; the empty shells of this form were abundant on the east beach at the Chandeleur Islands.

Ostrea virginica; the American oyster, is abundant in all of the shallow bays and bayous in the marsh along the coast.

Pecten irradians; very abundant on the shallow flats on

the east side of the Chandeleur Islands; the empty shells of this form are found on beaches all along the coast.

Margitiphora radiata; beach east of jetties at Cameron.

Rangia cuneata; from the Chandeleur Islands (Cowles) 1904.

Tellina alternata; found on sand flats above low water at the Chandeleur Islands, empty shells found on the beach at Cameron.

Mactra brasiliana; empty shells of this form found on the beach at Cameron, the Chandeleur Islands, and at South West Pass.

Mactra sollidissima var. similis; empty shells found commonly along the coast.

Gnathodon cuneatus; this form, commonly called "clam" in this region, occurs in abundance in the waters near the coast. Immense banks of the dead shells of this mollusc are found along the coast, in some instances at points now far removed from any body of water.

Venus mercenaria; the "little neck clam" or "quahog", occurs in abundance on the sandy shoals at the Chandeleur Islands, the empty shells are frequently found at Cameron and at other points along the coast.

Venus campechiensis; found rarely at Cameron and at the Chandeleur Islands.

Venus varicosa; the empty shells of this mollusc always with a Gorgonia attached are frequently found on the beach at Cameron and at the Chandeleur Islands.

Dosinia discus; found on sand flats at the Chandeleur Islands.

Callista gigantea; a very few specimens on the beach at the Chandeleur Islands.

Petricola pholadiformis; empty shells common on the beach at Cameron, Southwest Pass, and the Chandeleur Islands.

Cardium magnum; the empty shells of this large "cockle" are found along the coast. Live specimens were taken at the Chandeleur Islands in abundance.

Cardium robustum, taken at the Chandeleur Islands by Dr. Cowles in 1904.

Cardium muricatum; taken at the Chandeleur Islands by Dr. Cowles in 1904.

Callocardia texasiana; taken at the Chandeleur Islands by Dr. Cowles in 1904.

Solen americanus; taken at Cameron and at the Chandeleur Islands.

Solen viridis; found in the sand flats at Cameron.

Tagelus gibbus;

Tagelus diversus; these two racoos clams were abundant on the flats at the Chandeleur Islands.

Pholas costatus; this form, known to the fishermen as a "clam", is abundant at all points on the Louisiana coast where any collecting has been done.

Martesia striata; a burrowing clam, is found in oyster and Venus shells at several points on the coast; large numbers of this form are frequently found in wreckage in the gulf.

Labiosa caniculata;

Labiosa lineata; the shells of both these forms are abundant on the beach at Cameron, South West Pass, and the Chandeleur Islands.

Lucina floridana; taken on sand flats at the Chandeleur Islands.

Toredo sp.; a ship worm, is very abundant in the waters of the gulf and does much damage to wharf piles and boats.

CHORDATA.

Balanoglossus sp.; the burrows of a *balonoglossus,* were very abundant on the sand flats at the Chandeleur Islands.

Botryllus sp.; abundant on the eel grass at the Chandeleur Islands.

Molgula sp.; found on floating wood in tide pools at the Chandeleur Islands.

Pisces;

Scoliodon terrae-novae;

Sphyrna tiburno; both these sharks occur in the gulf at Cameron.

Dasyatis say; the southern sting ray, is very abundant in the gulf.

Pteroplates maclura; taken in the gulf at Cameron.

Pristis pectinatus; found occasionally at Cameron.

The following teleosts occur so generally in the waters on the coast that no record of localities where they have been taken is necessary.

Lepisosteus tristoechus; Felichthys marinus; Ictalurus punctatus; Ictiobus cyprinella; Megalops atlanticus; Prionotus tribulus; Gobiosox virgulatus; Scomberomorus maculatus; Chloroscombus chrysurus; Cynoscion nebulosus; Cynoscion regalis; Chylomycterus schopfi; Pomatomus saltatrix; Chaetodipterus faber; Sciaena ocellata; Mugil cephalus; Micropogon undulatus; Archosargus prabatocephalus; Siphostoma sp.; Blennius sp.; Tylosurus acus; Trichiurus lepturus; Silene vomer; Althernia laticeps; Lactophrys trigonus; Ogcocephalus vespertitio.

The Leaves

AND

Salt-Secreting Cells of Spartina Stricta.

By F. H. BILLINGS, Louisiana University,

BATON ROUGE, LA.

The plant described in this paper under Spartina stricta, is improperly named according to Merrill (a). In his monograph he states that the species, stricta, is not found in this country, but is European. Others, as Small (b) and Chapman (c) describe a Spartina stricta which answers the description of the plant here considered, so that this name can be employed on good authority.

The grass grows in salt marshes, or brackish-water marshes along our coast, and is abundant in the vicinity of the Gulf Biologic Station at the mouth of Calcasieu Pass. During a period of excessive rainfall, the pass contains fresh water, so that the roots of the grass may be bathed in water of densities varying from salt water to fresh.

The leaves of the grass are two to three feet in length, are narrow, and have longitudinal grooves on the ventral side. When drying, the leaves fold or roll lengthwise, so as to enclose the ventral surface. This movement is facilitated by the presence of the grooves. The longitudinal folding is manifestly a protective feature which reduces the transpiring surface, thus guarding against too great a water loss. Such a movement is characteristic of many xerophytes, some of which have rolled

leaves as a permanent condition of their foliage. A cross section of a leaf of Spartina stricta exhibits xeropnytic structure, although the plant lives in abundance of water. Water inhabiting plants showing this structure, such as rushes, sedges, flags and the like, are as yet a puzzle to botanists. Just why a

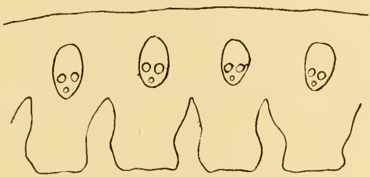

FIGURE 1.

Diagrammatic cross section of a portion of leaf of Spartina stricta showing grooves.

species whose roots are in contact with abundant and perennial water supply should show every evidence of suffering from drouth is still unknown, but it is conjectured that the water contains something in solution which is injurious to vegetable tissue; or else the reflection of the sun on the water causes excessive heat and consequent rapid evaporation of water from the leaf surface. Of the two, the former conjecture seems the more likely, and it will be of interest to note that Spartina stricta offers some evidence in support of this theory.

Stomata are located on the inner or ventral surface, and are found only on the sides of the grooves. Their presence here is evidently for protection, as, when the leaves are in a rolled condition, the walls of the grooves approach, thus reducing the air spaces between them, or obliterating them. In this condition the mouths of the stomata are brought into contact with the opposite walls of the grooves instead of air spaces into which the product of transpiration might be emptied.

It is on the walls of the grooves that the salt-secreting cells

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(a) North American species of Spartina.

(b) Flora of the Southeastern United States.

(c) Flora of the Southern States.

are found. The epidermis consists of a single layer of cells with thickened outer walls. Many of the cells have projections extending into the air spaces. The projections or processes are usually less than the diameter of the cells from which they arise and vary in number from one to several for each cell that may bear them. In form they are tapering-tubular, and have a hollow center which is continuous with the cavity of the epidermal cell. The end of the projection is closed by a wall which is thinner than any other portion of the wall of the cell.

If a section of the leaf is made, the processes will, in many instances, possess droplets of liquid of varying sizes, borne at the tips. The size of the droplet of any process is perhaps roughly commensurate with the time the secretion has been exuding. This remains true however only till the drops become confluent.

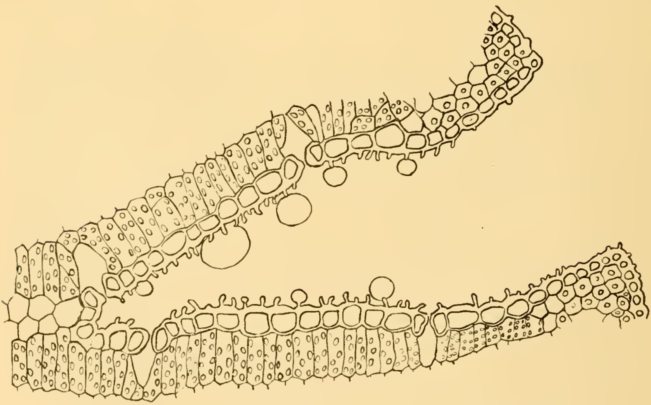

FIGURE 2.

Cross section of a groove showing epidermal processes, some of which have drops of exudate.

Macroscopically, the leaf appears covered with tiny, clear beads of exudate that become dried sooner or later, leaving a salty incrustation that possesses the property of deliquescence.

Plant secretory cells which yield watery exudates are in general termed hydathodes by Haberlandt. (d) In the present instance it is evident that the epidermal cell is the hydathode and the process merely a conduit, in which the extremity is closed.

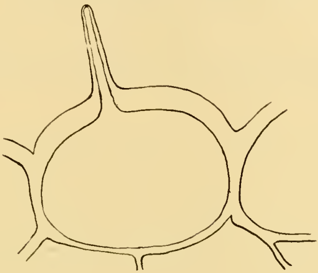

FIGURE 3.
An epidermal cell showing a process very highly magnified.

A hydathode resembling the one found in Spartina stricta has been described by Heberlandt (e). It is found in Gonocaryum, one of the Icacinaceae. A tubular papilla rises from the epidermal cell, as in Spartina, but instead of the end being closed by a cellulose wall, it is closed by a mucilaginous cap in the center of which the canal opens. After a heavy rain the cap may be washed away, when the canal is unstopped. Haberlandt says that the function of this hydathode is the same as that of the ordinary water pore in that it serves as a means of escape of water in liquid form, or when water in gaseous form can not escape by the usual process of transpiration. He says that there is no protoplasmic contents of the canal in the Gonocaryum hydathode. If there is any protoplasm in the canal of the Spartina hydathode it is not recognizable by an ordinary oil-immersion lens. The secretion of salty solutions by plants is generally associated with the metabolism of xerophytes, or plants living in

(d) Physiologische Pflanzenanatomie.
(e) loc. cit.

drouth conditions. Volkens (f) found that salt is secreted by various desert Tamaricaceae. An analysis of the exudate showed that the chief constituents are the chlorides of sodium, calcium and magnesium. As these salts are more or less deliquescent, Volkens thinks that they serve to gather water at night from the atmosphere, so that the plant is enabled to acquire moisture which would otherwise be unavailable. Haberlandt thinks, and doubtless rightly, that the plant would not be able to extract water from solutions as concentrated as those in which the salts are dissolved.

Marloth (g) thinks that the white crusts prevent the too rapid cooling by evaporation of water from the leaf surface at night. Haberlandt (h) offers the most plausible theory when he states that the salt secretion is to reduce the accumulation of inorganic material. Such material might arise from the katabolism of the plant, or might be absorbed with the water of transpiration in amounts harmful to the plant tissues. In either case, direct excretion would prove of value. Especially would this be the case in plants living in salt or brackish water, where the concentration of the water forbids abundant absorption. If a plant like Spartina can get rid of a portion of the salt absorbed it would be enabled to absorb just that more water, and with it the salts necessary in the synthetic processes.

The manner in which secretion takes place in Spartina is as yet undetermined; though from appearances, it would seem to be due to exudation pressure in the epidermal cells.

(f) Die Flora der aegyptisch-arabischen Wuste.

(g) Zur Bedeutung der Salz abscheidenden Drusen der Tamarascineen.

(h) loc. citt.

A Second Contribution

TO THE

ENTOMOLOGY

OF THE

Region of the Gulf Biologic Station.

By JAMES S. HINE, Columbus, Ohio.

In the second report of the Gulf Biologic Station a list of insects collected in 1903 was published. I spent some time in 1905 during the months of June and July in the employ of the Station and the Louisiana Crop Pest Commission, and the list offered at this time is composed of species that were not determined in 1903, and those that have been identified from the collections of 1905. There are still a number of undetermined species which are held for a future report.

Director B. H. Guilbeau of the Station suggested the work and manifested an interest in it; he also helped in the collecting. Mr. Robert Tillery, under the direction of Mr. Guilbeau, did much of the collecting, and others in the employ of the Station and the Crop Pest Commission have contributed to the work in various ways. The drawings for the accompanying plates were mostly made by Miss L. C. Riddle, of Columbus. Many of the determinations were made by different persons who are mentioned in connection with the order of insects in which help was given. To all who have helped in the work of making this list possible I wish to express my appreciation.

A number of forms are of more or less interest from an economic standpoint, and others on account of the fact that they are considered of rare occurrence. Therefore it seems worth while to offer notes concerning some of them.

The *predaceous insects* of any localitiy are attractive for study. At Cameron there is a great deal of sandy soil and

certain forms are attracted by such conditions. Many species of Hymenoptera excavate burrows in the sand, and carry in spiders and insects to feed their young upon. Other species are mud-daubers and fasten their neatly moulded nests to various objects, especially to unexposed parts of buildings. Peloppeus cementarius is very abundant and form a single newly constructed cell; I took eleven medium sized spiders with an egg of the wasp attached to one of them. In certain places one frequently sees the spider wasps, Pompilidae, dragging a spider too large for it to carry, and other species of wasps were often observed catching flies in various places.

Members of the Bembecidae are of especial interest as they feed their young on insects that they are able to capture. Five specimens of this family are known from Cameron; Monedula carolina, Bembex belfragei, Sphecius speciosus, Bembidula fodius and Microbembex monodonta. The first two were observed to be important enemies of horseflies which are very numerous and annoying in the region, and the third is known as the cicada-killer because it feeds its young on Cicada. The last one has been seen carrying horseflies of the genus Chrysops. All the species appear to be governed by circumstances, however, for if their usual species cannot be procured others are substituted.

A predaceous insect of special interest, on account of its uncommon occurrence, is one of the mantids, Brunneria borealis, which is figured on plate II. Several specimens of this species were taken but all of them were immature. The insect was described by Dr. Scudder from a specimen procured on the Gulf coast of Texas, and it is stated that the genus otherwise only contains South American species. It is a notable addition to the known fauna of Louisiana.

Seven species of beetles of the family Cicindelidae were identified. Some of these are abundant in individuals; the adults run over the sand and catch small insects of various orders, while the larvae construct burrows and station themselves with their sharp jaws at the surface and await the appearance of some insect suitable for food.

Several species of Neuroptera were taken. The larvae of

some of these are known as ant lions. Many of these larvae excavated their pitfalls under the station building and many small insects were preyed upon by them. The adults were taken commonly while sweeping with a net in tall grass.

Several species of the large robber flies are common and it is pleasant to watch their cunning ways. They do not appear to have as much choice in taking their food as the wasp. They station themselves on the ground or on a leaf or in some other place and remain motionless until some insect comes near enough for them to make an attempt at capturing it, when they are off like a dart and in full pursuit before the chosen victim is hardly aware of their presence. They do not attend their young as the wasps do, so the insects taken are used as food for themselves. Members of the order Odonata are known as mosquito hawks, and the name is an appropriate one, especially for some of the larger species. Their food is not entirely mosquitoes it is true, but there are times at Cameron when a large percentage is made up of these pests. Of the eighteen species taken, Anax junius is perhaps of most importance on account of its abundance, but the others are worthy of consideration, even the smallest of them. While the large species are feeding on the wing the small ones are flying from one perch to another along the edges of pools and ponds feeding on such small insects as they can procure. Mosquitoes just emerged are not active on the wing and are easily captured by such small species as belong to genera Lestes, Ischnura and Enallagma.

Ischnura prognata is an insect worth mentioning here because it is considered as a very rare species. Hagen described the male from a specimen which was taken in Virginia. The female was not described until two years ago when Williamson procured specimens near Nashville, Tennessee. His description is published in Entomological News for September, 1903. Over twenty specimens of this species were taken at Cameron in a single day, but, although I looked for it several times thereafter, no more were taken. On the day when specimens were collected the wind was blowing from the south and all were found on the leward side of the laboratory. It is a very weak flyer but on account of its color is very hard to see among the green foliage. Para-

sitic species are not as conspicuous as the predaceous, but some of the common Tachina flies were plentiful. About a dozen species of the family were noted, Archytas analis and Frontina aletiae being among the most often observed. Not many parasitic Hymenoptera were taken but particular attention was not given that group. Quite often a specimen of Polistes was observed that showed the work of a member of the family Stylopidae.

There are those who ask regarding the benefits to be derived from a study of predaceous and parasitic insects. True, these work just the same when they are receiving no attention from anyone but the results that have been and are being accomplished with them after their habits are fully known is proof enough that we do not realize their possibilities at the present time. In order that they be protected they must be known by the people in general, and in order that we know what they are capable of accomplishing a full understanding of their habits is necessary. It would seem that the subject is one most worthy of attention.

Scale insects are not plentiful at Cameron, but one species attracted my attention especially. A common tree grows in the locality, commonly known as the toothache tree; by botanists called Xanthoxylon clava-herculis. A scale insect, Ceroplastes cirripediformis, is abundant on this tree, in fact, some trees are literally covered with it. The scale is rather large and must secrete a great deal of honey dew, for insects of different orders were attracted in large numbers. Many species not seen anywhere else were plentiful enough here to make them appear common. I did not keep a complete list of all the species taken on the infested trees, but the following are some of the more conspicuous: the screwworm fly was represented by more individuals than any other; horseflies of two or three species, especially the males, were conspicuous; Tachina flies of various species were plentiful; and several kinds of predaceous wasps, as Monedula carolina, Sulius fulvicornis and others, continually reminded one of their presence by the buzzing sound produced by their wings in coming and going or in moving from one branch to another.

Injurious insects received some attention, but with most of them nothing in the way of remedies was attempted. The white ant was found to be plentiful, but was not observed to be doing any injury in the vicinity of the Station. Many colonies were located on the higher ground under decaying boards and other pieces of wood. A species of ant, Solenopsis geminata, determined for me by Professor Wheeler of the American Museum, is very plentiful and has some habits which are worthy of mention. They were often found in the burrows of predaceous wasps under circumstances which led one to suspect that they killed the larvae and used them for food. The ant is one that must be guarded against while making collections of insects, for if the recently collected specimens are left exposed often much damage is done. During my first stay at the Station the species was very troublesome, for not being acquainted with its habits, pined insects were placed on my table in boxes with covers that did not fit tightly, and before I was aware of its presence many valuable specimens were destroyed. The number of specimens of the ant that took part in the work of destruction cannot be estimated, but they formed a continuous line of individuals from the ground up the foundation and across the floor to the table from which the return was made by the same route. Like other ants they hesitate to make an attempt to cross water and I found that thorough protection was given to anything that was placed where the ants had to cross water in order to get to it. Solonopsis geminata appears to be almost omnivorous in its food habits, and for that reason is especially annoying.

Heliothis armiger, the larva of which is commonly known as the cotton-boll worm, is plentiful, but as I observed its work it is more destructive to corn than to cotton in that section. The leaves and stalks of growing corn in July showed much injury from its attacks.

The garden webworm, Loxostege similalis, is a common species. In July the adults were plentiful, and in passing through the fields one could see them flying up on every side. The larvae feed on almost all kinds of plants and sometimes do much injury to cotton and corn. The moth is about three-fourths of an inch in expanse, and is variable in color, through different shades of yellow.

A species of wild grape grows commonly in the woods, and furnishes food for the larvae of the grape leaffolder, Desmia funeralis. The adults were common in July. The species causes more or less damage to cultivated grapes in various parts of the country.

The southern corn leaf beetle, Myochrous denticollis, is a common insect at Cameron. This species has been reported as injuring corn in Tensas parish, Louisiana, and in other States. After a freshet which flooded some low grass land near the Station building the beetles crawled upon the grass and weeds that protruded above water in large numbers. In this case the insect must have depended upon grass entirely for food for there was no corn at hand for it to feed upon.

The region in the vicinity of the Station is well suited for stock raising and a great many cattle and horses are raised; therefore the insects that interfere with these interests in any way are of consequence.

The horn fly, Haematobia serrata, and the screw worm fly, Chrysomyia macellaria, are plentiful and the former is a pest which does much injury to cattle. It may be repelled by spraying animals with a mixture made of three gallons of kerosene, one quart of pine tar and one pint of carbolic acid. Many of the specimens that are on the animals at the time they are being sprayed are killed. A single spraying is of short duration and for that reason the mixture is not as popular as it would be if it lasted longer.

The Hippelates flies of two or more species are plentiful. They are exceedingly small but their size does not hinder them from doing much injury. They do not appear to fly at night but they were observed around cattle and horses very early in the morning and continuously during the remainder of the day. Hippelates flavipes is charged with facilitating the spread of the disease known as pinkeye.

Several species of horseflies have been taken at Cameron, but three of these are usually more plentiful than the others, and are so near in size and coloration that they are often taken for the same. They have been figured and enlarged views of

the heads of the females are given to point out the characters that are of value in separating them.

Tabanus costalis has the stripes on the sides of the abdomen continuous, the front border of the wing is brown and in living specimens the eye is green crossed by a single purple band. Tabanus lineola has the markings on the sides of the abdomen in the form of a series of elongate spots which do not form continuous stripes; the wings are hyaline all over and the eyes each have other purple markings besides the single band. Tabanus 5-vittatus is the largest of the three. It has the abdomen almost as in costalis and the wings as in lineola. The color of the eyes in living specimens is of the same pattern as in lineola but the purple markings are not so extended. These horseflies are extensively preyed upon by several of the predaceous insects previously given. A figure of Bembex belfragei is given in the plate.

Something has been done in some of the States toward an investigation of the insects that are injurious to native grasses. Professor Osborn, working in Iowa, and Professor Bruner in Nebraska, each have published on the subject. At first thought this may appear as a minor matter, but when we think that there are many species of native grasses and that nearly every one of them has its particular insect, and some two or more, besides the large number of general feeders, it is easy to see that the pastures and meadows would be much more productive if it were not for the myriads of grass feeding species. The insects that are worthy of mention from the standpoint of injury to grasses at Cameron are the leafhoppers and the grasshoppers, although several moths and other insects known to feed on these plants were taken and their names are included in the accompanying list. Tettigonia harti, Draeculacephala mollipes and others were exceedingly abundant over an extensive territory, and are, perhaps, among the more destructive leafhoppers of the region. Several of the common species of grasshoppers in the locality are abundant in individuals and these wherever found are enormous feeders.

Plate I was made under the direction of Professor Osborn and shows three species of leafhoppers of special interest on

account of their unusual occurrence in collections that have been studied.

Not much was observed regarding the habits of Stobaera minuta and Prokelesia setigera, but both were taken from grasses by sweeping and the former was common enough to indicate that it must be of some injury in pastures. Both species were described in Volume V. of the Ohio Naturalist for the first time, and Prokelesia was offered as a name for a new genus.

Tinobregmus vittatus was taken from a common plant, Iva frutescens, which appears to be confined to the salt marshes where it grows in abundance and an interesting lot of species of different orders feed upon it. The insect was named by Van Duzee in 1894, from female specimens taken in Florida. His description was published in the Bulletin of the Buffalo Society of Natural History. In 1903 Professor Osborn described the male in the Ohio Naturalist. In the plate the male, female and larva are figured. The three are so different in general appearance that they are not easily associated at first, but on closer examination are seen to have an anatomical agreement which clearly fixes their identity.

In the larva the abdomen is flexed upward at nearly right angles to the rest of the body and the longitudinal ridges on the front are much more pronounced than in the adult. A peculiarity of the species is the very small scutellum. This is smaller in the male than in the female, but slightly larger in the larva than in the adult of either sex.

ODONATA.

The species preceded by an asterisk (*) were determined by E. B. Williamson of Bluffton, Indiana; the others were determined by myself.

*Lestes unguiculatus Hagen.
*Ischnura prognata Hagen.
*Enallagma signatum Hagen.
*Coryphaeschna ingens Rambur.
Epiaeschna heros Babr.
Pantala hymenaea Say.

*Tramea lacerata Hagen.
*Tramea onusta Hagen.
Libelllula auripennis Burm.
Lepthemis gravida Calvert.
Pachydiplax longipennis Burm.
Mesothemis simplicicollis Say.

ISOPTERA.

Termes flavipes Koll.

ORTHOPTERA.

The two species preceded by an asterisk (*) were determined by myself; the others by A. N. Caudell of the Bureau of Entomology at Washington.

Ischnoptera uhleriana Saussure.
*Brunneria borealis Scudder.
*Anisomorpha buprestoides Stoll.
Tettigidea lateralis Say.
Orphuella pratorum Scudder.
Orphulella picturata Scudder.
Chortophaga viridifasciata De Geer.
Encoptolophus costalis Scudder.
Trimerotropis citrina Scudder.
Melanoplus femur-rubrum De Geer.
Paraidemona mimica Scudder.

HEMIPTERA.

All the species were determined by Professor H. Osborn of the Ohio State University, Columbus.

Vanduzea vestita Godg.
Dictyophara curviceps Stal.
Ormenis pruinosa Say (pale var.)
Oliarus aridus Ball.
Stxobaera minuta Ocborn.
Prokelisia setigera Osborn.
Draeculacephala mollipes Say.
Agallia sanguinolenta Prov.

Corixa calva Say.
Notonecta undulata Say.
Anisops platycnemius Fieb.
Hydrometra martini Kirk.
Salda signoreti Guer.
Salda sphacelata Uhler.
Salda humilis Say.
Salda interstitialis Say.
Stenopoda culiciformis Fabr.
Atrachelus cinereus Fabr.
Fitchia nigrovittata Stal.
Oncopeltus fasciatus Dallas.
Corizus hyalinus Fabr.
Harmostets reflexulus Say.
Alydus pilosulus H. S.
Chariesterus antennator Fabr.
Pentatoma senilis Say.
Hymenarcys nervosa Say.
Brachymena arborea Say.
Cydnus compactus Uhler.
Cydnus obliquus Uhler.
Pangaeus rugifrons H. S.
Corimelaena nitiduloids Wolff.

NEUROPTERA.

Myrmeleon rusticus Hagen.

LEPIDOPTERA.

The species preceded by an asterisk (*) were determined by Dr. Dyar of the U. S. National Museum; the others were determined by myself.

Anosia plexippus Linn.
Anosia berenice Cramer.
Dione vanillae Linn.
Euptoieta claudia Cramer.
Phyciodes phaon Edw.
Pyrameis cardui Linn.

Pyrrhanaea andria Scudder.
Neonympha sosybius Fabr.
Libythea bachmanni Kirtland.
Thecia melinus Hubner.
Pieris protodice Boisd.
Terias lisa Boisd.
Papilio cresphontes Cramer.
Papilio philenor Linn.
Hesperia tessellata Scudder.
Deilephila lineata Fabr.
Utetheisa bella Linn.
Hyphantria textor Harris.
*Peridroma margaritosa Haw.
*Feltia annexa Treitschke.
*Feltia malefida Guen.
Heliothis armiger Hubner.
*Plusiodonta compressipalpis Guen.
*Tarache aprica Hubner.
*Acontia candefacta Hubner.
*Caenurgia convalescens Guen.
*Meliopotis nigrescens Grote.
*Remigia repanda Fabr.
Erebus odora Linn.
Desmia funeralis Hubner.
Diastictis fracturalis Zeller.
*Margaronia flegia Cramer.
Loxostege similalis Guen.
*Tholeria reversalis Guen.
*Pyrausta laticlavia G. and R.
*Pseudanaphora arcanella Clemens.

DIPTERA.

The names preceded by an asterisk (*) indicate determinations made by D. W. Coouillett of the U. S. National Museum; otherwise determinations were made by myself.

Spogostylum anale Say.
Exoprosopa fascioennis Say.
Phthiria sulphurea Loew.

Psilocephala pictipennis Wied.
Laphrystia sexfasciata Say.
Erax bastardii Maco.
Promachus rufipes Fabr.
Baccha clavata Fabr.
Allograpta fracta Osten Sacken.
Meromacrus acutus Fabr.
Tropidia quadrata Say.
*Hypostena variabilis Coo.
*Ervia triquetra Oliver.
*Frontina aletiae Riley.
Lucilia sericate Meigen.
Ophyra aenescens Wied.
*Limophora narona Walker.
*Caricea antica Walker.
*Acrosticta fulvipes Coq.
*Euxesta scoriacea Loew.
Caenia viridis Hine.
Hippelates plebejus Loew.
*Drosophila obesa Loew.
*Drosophila punctulata Loew.
*Drosophila quadrimaculata Walk.

COLEOPTERA.

The specimens preceded by an anterisk (*) were determined by Dr. Schwarz of the U. S. National Museum. Most of the others were determined by Mr. Chas. Dury of Cincinnati.

Tetracha virginica Linn.
Cicindela hamata Brulle.
Cicindela severa Laf.
Pasimachus punctulatus Hald.
Scarites subterraneus Fab.
Clivina analis Putz.
Bembidium contractum Say.
Tachys pallidus Chd.
Platynus punctiformis Say.
Galerita bicolor Drury.
Tetragonoderus intersectus Germ.

Chlaenius erythropus Germ.
Chlaenius vafer Lec.
Oodes lecontei Chd.
Agonoderus lineola Fab.
Agonoderus infuscatus Dej.
Harpalus caliginosus Fab.
Selenophorus pedicularius Dej.
Anisodactylus harpaloides Laf.
Anisodactylus rusticus Dej.
Laccophilus proximus Say.
Copelatus glypticus Say.
*Hydaticus bimarginatus Say.
Thermonectes basilaris Harr.
Dineutes assimilis Aute.
Hydrochus simplex Lec.
Hydrophilus nimbatus Say.
Hydrophilus striolatus Lec.
Berosus pantherinus Lec.
Berosus exiguus Say.
Phylhydnus ochraceus Mels.
Hydrocombus fimbriatus Mels.
*Pinophilus picipes Er.
Anisosticta seriata Mels.
Coccinella sanguinea Linn.
Coccinella oculata Fabr.
Chilocorus bivulnerus Mels.
*Acropteroxys inornata Rand.
Alaus lusciousus Hope.
Monocepidius lividus DeG.
Ludius texanus Lec.
Agrilus difficilis Gory.
Chauliognathus marginatus Fab.
Phanaeus difformis Lec.
Onthophagus Lecate Panz.
Onthophagus tuberculifrons Harold.
Ataenius stercorator Fab.
Aphodius lividus Oliv.
Aphodius rubeolus Beauv.

*Lachnosterna crinita Burm.
*Cyclocephala immaculata Oliv.
*Cyclocephala nigricollis Burm.
Cyclocephala villosa Burm.
Chalepus trachypygus Burm.
Mallodon dasystomus Say.
Mecas inornata Say.
Tetraopes basalis Lec.
Exema gibber Oliv.
*Cryptocephalus brunneovittatus Schaef.
Myochrous denticollis Say.
*Metachroma usta Lec.
*Colaspis brunnea Fab.
Diabrotica 12-punctata Oliv.
Diabrotica vittata Fab.
*Oedionychis interjectionis Cr.
Oedionychis petaurista Fab.
*Disonycha pennsylvanica Ill.
Disonycha collata Fab.
Monoxia puncticollis Say.
Galeruca integra Lec.
*Conoecus ovipennis Horn.
Eleodes veterator Horn.
Blapstinus fortis Lec.
Blapstinus pratenis Lec.
*Ulus elongatus Casey.
Mordella scutellaris Fab.
*Mordellistena nigricans Melsh.
*Mordellistena splendens Smith.
Anthicus cervinus Laf.
Conotrachelus similis Boh.
Sphenophorus pertinax Oliv.

HYMENOPTERA.

The species of this order preceded by an asterisk (*) were determined by E. S. G. Titus of the Bureau of Entomology at Washington; Bembidula fodiens and Microbembex monodonta

by Miss L. C. Riddle of Columbus; and, with the exception of three or four of the commoner species, the others by J. C. Bridwell at present located at Amherst, Massachusetts.

*Melanobracon simplex Cress.
Solenopsis geminata Fabr.
*Plesia hyalina Cress.
Discolia nobilitata Fabr.
*Elis plumipes Drury.
Elis octomaculata Say.
Pompilogastra aethiops Cress.
Arachnophroctonus ferrugineus Say.
*Poecilopompilus navus Cress.
Sulius fulvicornis Cress.
Chlorion bifoveolatum Tasch.
Chalybion caeruleum Linn.
Larra analis Fabr.
*Tachytes abdominalis Say.
*Tachytes distinctus Smith.
*Tachysphex terminata Smith.
Sphecius speciosus Drury.
Bembidula fodiens Hendl.
Microbembex monodonta Say.
Paranysson texanus Cress.
*Trypoxylon texense Sauss.
*Trypoxylon tridentatum Packard.
*Solenius texanus Cress.
Eumenes belfragei Cress.
Monobia quadridens Linn.
Ancistrocerus fulvipes Sauss.
Triepeolus lunatus Say.
Augochlora similis Robertson.
Melissodes bimaculata St. Farg.
*Entechnia taurea Say.
Bombus emericanorum Fabr.
Bombus scutellaris Cress.

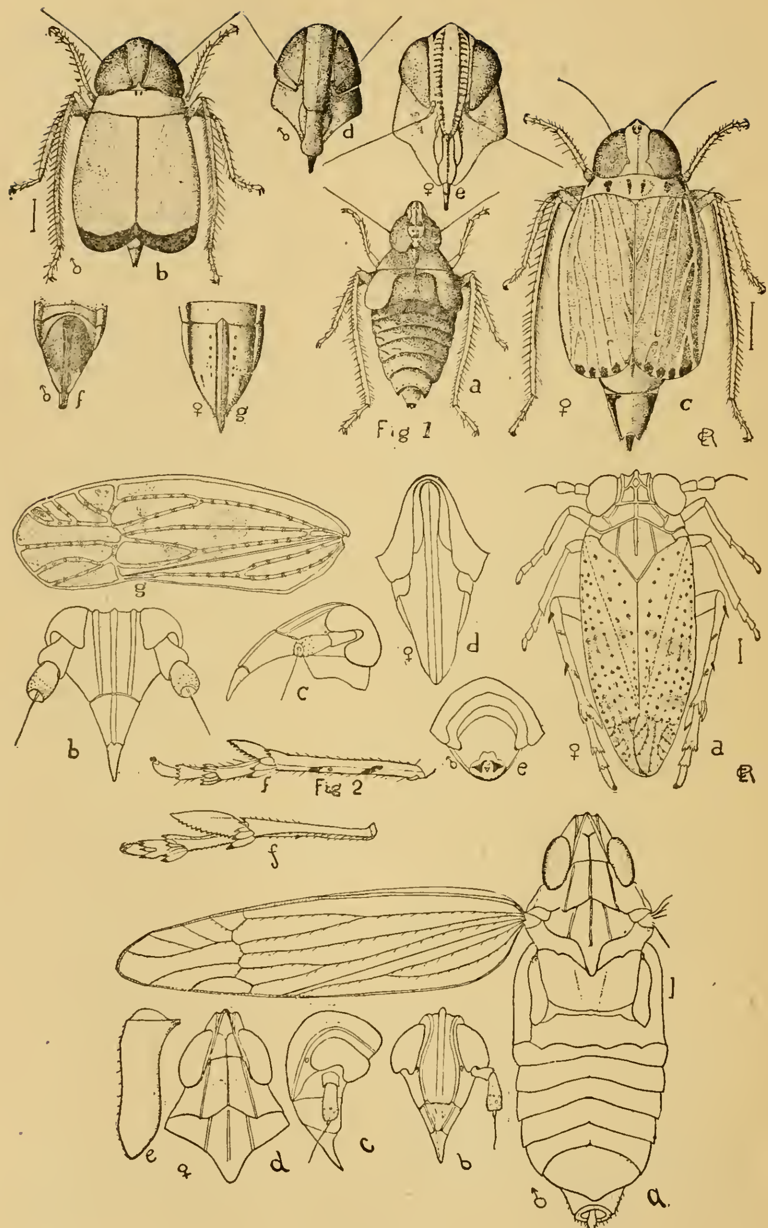

PLATE II.

EXPLANATION OF PLATE II.

FIGURE 1.

Tinobregmus vittatus Van Duzee. *a*, larva; *b*, male; *c*, female; *d*, face of male; *e*, face of female; *f*, male genitalia; *g*, female genitalia; (From drawings by Miss L. C. Riddle under direction of H. Osborn).

FIGURE 2.

Stobaera minuta Osborn. *a*, dorsal view of the adult; *b*, face; *c*, profile of head; *d*, female genitalia; *e*, male genitalia; *f*, leg; *g*, wing; (From drawings by Miss L. C. Riddle under direction of H. Osborn).

FIGURE 3.

Prokelisia setigera Osborn. *a*, dorsal view of male; *b*, face; *c*, profile of head; *d*, dorsal view of female; *e*, aborted wing; *f*, posterior leg; (From drawings by J. G. Sanders under direction of H. Osborn).

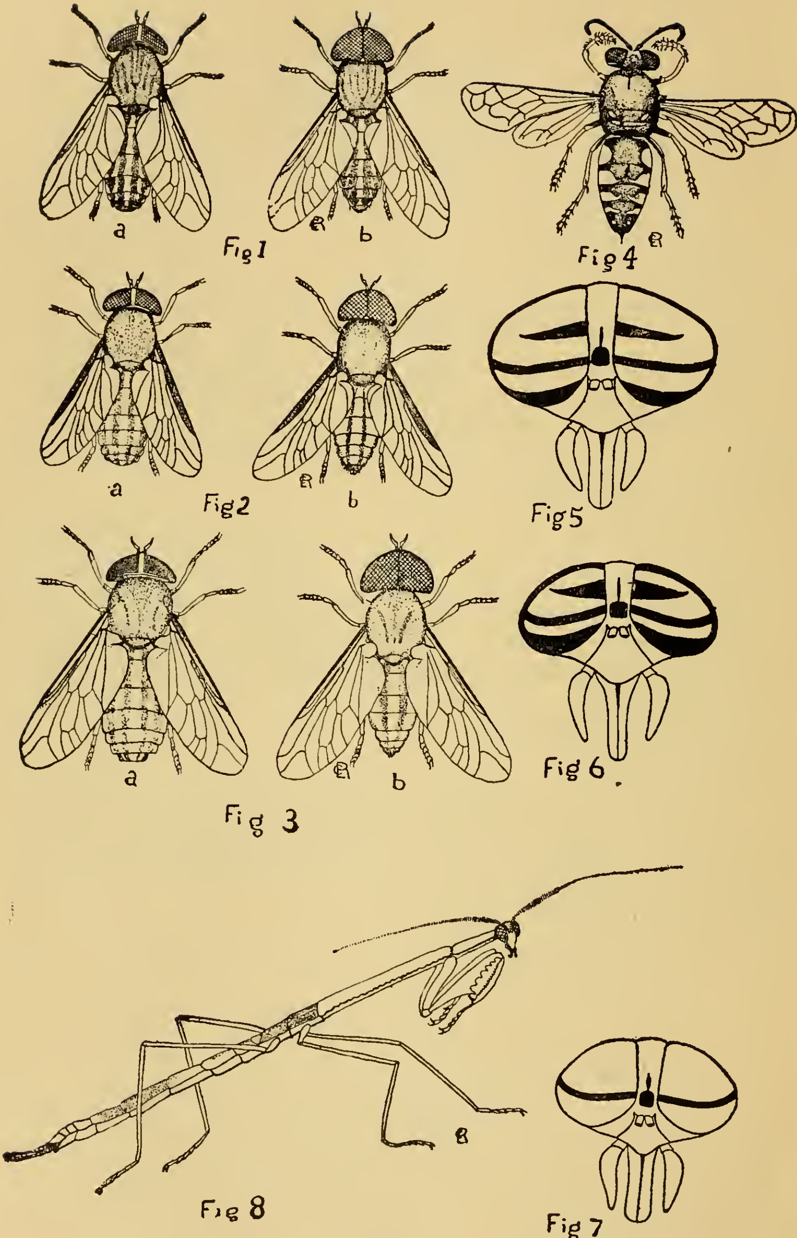

PLATE III.

EXPLANATION OF PLATE III.

Figure 1.

Tabanus lineola Fabricius. *a*, female; *b*, male; (Drawing by Miss L. C. Riddle).

Figure 2.

Tabanus costalis Wiedemann. *a*, female; *b*, male; (Drawing by Miss L. C. Riddle).

Figure 3.

Tabanus quinquevittatus Wiedemann. *a*, female; *b*, male; (Drawing by Miss L. C. Riddle).

Figure 4.

Bembex belfragei Cresson. (Drawing by Miss L. C. Riddle).

Figure 5.

Front view of the head of Tabanus quinquevittatus representing the coloration of the eyes. Black represents purple, white represents green.

Figure 6.

Front view of the head of Tabanus lineola.

Figure 7.

Front view of the head of Tabanus costalis.

Figure 8.

Brunneria borealis Scudder. The specimen from which the drawing was taken is immature. (Drawing by Miss L. C. Riddle).

Figure 8 is natural size, the others are enlarged.